PASTORALISTS' PERCEPTIONS AND RISK OF HUMAN BRUCELLOSIS IN KAJIADO COUNTY, KENYA

PENINA KAREAUKI MUTUA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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Penina Kareauki Mutua Date

This thesis has been submitted for examination with our approval as University supervisors

_____ _____

Prof. Philip Kitala (B.V.M., M Sc., PhD.) Date

_____ _____

Dr Peter B. Gathura (B.V.M., M Sc., PhD.) Date

_____ _____

Dr Joshua Onono (B.V.M., M Sc., PhD.) Date

DEDICATION

My first dedication of this research is to my husband Peter Mwangi and children Faith Muthoni, Grace Makena and Peace Mwangi, for their remarkable support during my research period. Secondly, is to my parents Gerald and Grace Mutua for their value for education which motivated me to come this far.

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ABBREVIATIONS AND ACRONYMS

ASAL	-Arid and Semi Arid Lands
ASDSP	-Agricultural Sector Development Support Program
CAC	-CODEX Alimentarius Commission
CAHN	- Caribbean Animal Health Network
CFSPH	-Centre for Food Security and Public Health
CCPP	-Contagious Caprine Pleura Pneumonia
DVS	-Department of Veterinary Services
ECF	-East Coast Fever
ELISA	- Enzyme-Linked Immuno-Sorbent Assay
FAO	-Food and Agriculture Organization
FGD	-Focus Group Discussion
FMD	-Foot and Mouth Disease
GOK	-Government of Kenya
IFAD	-International Fund for Agricultural Development
KNBS	-Kenya National Bureau of Statistics
LSD	-Lumpy Skin Disease
MRT	-Milk Ring Test
OIE	- World Organisation for Animal Health
PPR	- Peste des Petits Ruminants
REGLAP	- Regional Learning and Advocacy Programme
VEEU	-Veterinary Epidemiology and Economic Unit

WHO	-World Health Organization
ZDU	-Zoonotic Disease Unit

ABSTRACT

Brucellosis is one of the neglected zoonotic diseases with a worldwide distribution. Although some countries are reported to be free from brucellosis, there are threats of the disease due to people returning from endemic countries. The disease is common in the developing countries and more prevalent in the pastoralists' communities. It is estimated that about 16% of the livestock in sub-Saharan Africa are infected with brucellosis. Man gets the disease by consuming infected animal products or having skin contact with infected material. Awareness of brucellosis by the pastoralists in arid and semi arid land (ASAL) is not understood given that they constitutes about 80% of the land and supports nearly one third of the human population and 70% of the national livestock. This study aimed at assessing the level of brucellosis awareness among the pastoralists in Kajiado County, and their risk of exposure to the disease. The study was done in Kajiado Central and Isinya sub-counties. The study population was categorized into two: the rural and the peri-urban pastoralists. Data on pastoralists' knowledge, practices and perceptions with regard to the prevalent livestock diseases was obtained. This was done through published participatory methods (listing, pair-wise ranking, disease matrix scoring and proportional piling).Exposure risk assessment was done as per the CODEX Alimentarius framework (Hazard identification, hazard characterization, exposure assessment and risk estimation). The livestock diseases were ranked based on their perceived impact on pastoralist's community. The identified zoonotic diseases (brucellosis and anthrax) were associated with less impact hence were ranked low. However, highly ranked livestock diseases included contagious caprine pleura-pneumonia (Z=4.53), lumpy skin disease (Z=1.97)

and foot and mouth disease (Z=1.28). The level of agreement on the rank order by various groups was calculated using the Kendall's coefficient of concordance (Kendall's coefficient W). The value of the coefficient 'W' was 0.007, which was interpreted as weak. This could be explained by the diversity between the production systems recruited in the study. The impact of brucellosis on livestock production parameters was also low compared to other listed livestock diseases. In addition, the pastoralists' knowledge on brucellosis infection in animals with regard to its symptoms, transmission and control was generally low. The identified potential pathways of exposure included consumption of unpasteurized milk, handling infected materials without gloves and consumption of raw meat and raw blood. The first two were associated with high risk of exposure, while the last two were associated with medium risk of exposure among the rural pastoralists. In the peri-urban group however, the risk associated with handling infected birth products without gloves and consumption of unpasteurized milk was low. Similarly, the risk attributed to consumption of raw meat and blood was considered very low as the practice is rare in the peri-urban population. Overall, the rural pastoralists were at a higher risk of exposure compared to the peri-urban pastoralists, due to their habitual cultural practices. These include consumption of raw animal products like meat and milk and handling birth products without protective gear. As a result, public education targeting these vulnerable groups is the recommended action plan to mitigate impacts of brucellosis in the affected systems in Kenya.

CHAPTER ONE

1 INTRODUCTION

1.1 Background

Brucellosis is one of the neglected bacterial zoonoses with worldwide distribution. It is caused by various *Brucella species,* which are gram negative facultative intracellular coccobacilli organisms. About ten different *Brucella species* have been identified and may affect both man and animals (Galińska and Zagórski, 2013). The species with significant importance in man are *Brucella abortus, Brucella melitensis* and *Brucella suis*(Godfroid *et al.,* 2011). The disease is known to be prevalent at the interface between domestic and wild animals (Muñoz *et al.,* 2010; Godfroid *et al.,* 2013).

Brucellosis is reported in 56 countries with more than 500,000 new human cases reported annually (Seimenis *et al.,* 2006; Christou, 2011). The disease is endemic in most of the developing and low income countries and its incidence is reported to be higher in low income countries. This may be attributed to factors such as poor disease control programs, increased international travel and low awareness levels among others (Pappas *et al.,* 2006; Farina *et al.,* 2008). Scarcity of the data on brucellosis, under-recognition by health care providers and inadequate laboratory diagnostics are some of the factors contributing to underestimation of the true disease burden (Dean *et al.,* 2012b ,Rubach*etal.,*2013).

Brucellosis has been recognized as a notifiable disease in many countries (Vassalos *etal.,* 2009). Its economic implications are linked to the losses in animal production and medical care for the people infected (Corbel, 2006). In addition, some Brucella species are considered to have the potential to be developed into biological weapons (Guihot *et al.*, 2004; Anderson and Bokor, 2012).

Brucellosis in animals is a herd problem and it is spread by direct or indirect contact with infected or contaminated materials(Diaz Aparicio, 2013). In man however, transmission is mainly by consumption of contaminated animal products or by handling infected aborted materials (Karimuribo *et al.,* 2007). Most of the human brucellosis cases have their origin from animals (Hou *et al.,* 2013).

Various routes of inter-person transmission have been described, though, rare. Such routes are sexual transmission from man to woman (Meltzer *et al.,* 2010), trans-placental transmission from mother to child (Mosayebi *et al.,* 2005) and mother to child through breast milk (Palanduz *et al.,* 2000; Carrera *et al.,* 2006).

In most developing countries, efforts to control brucellosis have been compromised by lack of adequate data (Seleem *et al.,* 2010; Dean *et al.,* 2012a). In Kenya, although brucellosis has been reported in various parts of the country, the data on its occurrence and exposure factors is still very scarce. A recent analysis revealed that brucellosis is widespread in the country (Njeru *et al.,* 2016). Policies like prevalence surveys, vaccination and test-and-slaughter methods have been put in place for brucellosis control. However, studies have not shown evidence of their implementation (Njeru *et al.,* 2016).

Successful implementation of these policies is thwarted by inadequate and non-sustainable resources. The control is further complicated by the mixed production systems and inadequate control of animal movement commonly practiced in pastoral areas (Ducrotoy *et al.,* 2015; Njeru *et al.,* 2016b). Constant interaction at the livestock-wildlife interface and porous borders enhance spread and maintenance of brucellosis in both animal and human populations(Godfroid *et al.,* 2013; Ogola *et al.,* 2014).

Pastoralism is an economic and social system practiced in many countries across the globe. It involves integration of crop production, livestock management, and conservation of natural resources (Koocheki and Gliessman, 2005). In Sub-Saharan Africa, approximately 16% of the population depend on a pastoral ecosystem (Racloz *et al.,* 2013) and solely on livestock for their livelihood (Mangen *et al.,* 2002). It is estimated that over 16% of the livestock in Africa have brucellosis (Kiambi, 2012). Data in Kenya indicate that animal brucellosis is reported annually especially from the pastoralist areas (Kiambi, 2012). Human brucellosis prevalence is also reported in various pastoralist areas in the country (Maichomo *et al.,* 2000; Richards *et al.,* 2010). In both animals and humans, the prevalence is higher in pastoralist production systems compared to settled intensive systems (Osoro *et al.,* 2015).

In Kenya, about 89% of the land comprises ASAL. This accommodates nearly36% of the human population,70% of the national livestock and 90% of the wild-life (GoK, 2015). Most pastoralists have low access to social services like education and health (Duba *et al.,* 2001; Bechir, *et al.,* 2012). Pastoralists are highly dependent on livestock for nutritional, economic and social utilization (Zinsstag *et al.,* 2006; Bechir, *et al.,* 2012).

Cultural practises such as consumption of raw animal products like unpasteurized milk, raw meat and blood is a common practice in the pastoralist communities (Adesokan *et al.,* 2013). Such practises enhance spread of zoonotic diseases among the pastoralists communities' population(John *et al.,* 2010). Other practises such as the increased mobility of pastoralist and their livestock in search for pasture and communal watering grounds also augment spread of infectious diseases in animal population.

Disease surveillance in Kenya is a responsibility of the Veterinary Epidemiology and Economics Unit (VEEU), under the Department of Veterinary Services. Various universities and research institutions have also conducted various sero-prevalence studies on brucellosis in different parts of the country. These studies have reported presence of brucellosis reactors in both domestic and wild animals (Waghela and Karstad, 1986;Paling *et al.,*1988; Muendo *et al.,* 2012). The disease prevalence varies across the various production systems. It is reported to be higher among the pastoralist production systems, as compared to the settled communities (Kadohira *et al.,*1997). This may partly be attributed to increased animal movement, mixing different animal species and the increased conflicts at the livestock-wildlife interface (Godfroid *et al.,* 2013; Njeru *et al.,* 2016).

1.2 Hypothesis

i. Pastoralists in Kajiado County lack knowledge on animal and human brucellosis
ii. The risk of exposure to brucellosis among the pastoralists in Kajiado County is high

1.3 Broad objective

To assess the pastoralists' perception and risk of human brucellosis in Kajiado County, Kenya

1.3.1 Specific objectives

i. To describe the knowledge, practices and perception (KAP analysis) of pastoralists on brucellosis within the Kajiado agro-ecosystem.

ii. Assess the risk of exposure to brucellosis by household members within Kajiado agro-ecosystem.

1.4 Justification for the study

Most of the studies conducted in Kenya aimed at determining the prevalence and the risk factors associated with the spread of brucellosis both in livestock and human populations (Osoro *et al.,* 2015; Kang'ethe *et al.,* 2007). However, no study has examined the contribution of these risk practices to exposure of household members to brucellosis. In addition, the perception and knowledge of pastoralists on effects of brucellosis to livestock production has not been described. This study begins to examine the role of pastoralist community in disease control with a view of harnessing best cultural practices which can be integrated in the brucellosis control policy within pastoral areas.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Brief history of brucellosis

Brucellosis was first discovered in the 1850s in Malta among the British army troops and was associated with consumption of milk from infected goats (Wyatt, 2013). Continued research has resulted in identification of ten *Brucella species* affecting human and animals (Galińska and Zagórski, 2013). The classification of these strains is based on the major reservoir thus are categorized as host specific. However, there is a high rate of cross infection across species and all of them can affect man under favourable conditions (Diaz Aparicio, 2013).

2.1.1 Epidemiology of brucellosis

Brucellosis is caused by small non-motile, non-spore forming aerobic gram-negative cocco-bacilli of the genus *Brucella* (Corbel, 2006). Out of the ten *Brucella species* identified, four of them are implicated in causing the disease in man. The most virulent strain causing the disease in man is *B. melitensis*, followed by *B. suis*, *B. abortus*, and *B. canis* (Galińska and Zagórski, 2013).The severity of the disease in man is highly influenced by the type of the causative organism and its source (Corbel, 2006). Among the domestic ruminants, *B. abortus* is mostly associated with cattle, *B. melitensis* with sheep and goats, *B. ovis* with sheep and *B. suis* with pigs(Corbel, 2006; Diaz Aparicio,

2013). However, *Brucella ovis* and *Brucella suis* biovars 5 have not been clearly implicated to cause disease in man (Corbel, 2006).

Both wild and domestic ruminants are highly susceptible to brucellosis (Corbel, 2006). The disease has been reported in a number of wild animals including water buffalos, bison, elk and African antelopes (Godfroid, 2002; Cvetnic *et al.,* 2003;Gomo *et al.,* 2012). They can therefore serve as a reservoir and source of infection where there is domestic and wildlife interaction. Brucellosis has also been reported in camels and horses which had interactions with ruminants infected with *B. abortus* and *B. melitensis* (Diaz Aparicio, 2013; Schumaker, 2013). Pigs fed on whey have been shown to get infected with *brucella abortus*(Diaz Aparicio, 2013) thus can serve as reservoirs for infection where mixed livestock are kept. *B. abortus* has been experimentally demonstrated in dogs (Barr *et al.,* 1986; Baek *et al.,* 2003; Diaz Aparicio, 2013)and this can pose as a major risk where dogs are fed on aborted foetuses and placentas

Brucellosis has been reported in many countries worldwide. Although it has been controlled in some developed countries, it still poses a great public health problem especially in the Mediterranean region, western Asia, Latin America and parts of Africa (Corbel, 2006; Gwida *et al.,* 2010). In African countries, *B. abortus*, *B. melitensis* and *B. suis* have been isolated and are closely associated with strains in the Mediterranean basin (Lounes *et al.,* 2014; Ducrotoy *et al.,* 2015). Though the organisms have a strong affiliation to specific hosts, the same strain can cause the disease in various animal species and in man (Boschiroli *et al.,* 2001).

A study carried out in Africa on bloodstream infections in man revealed brucellosis as a major cause of bacteraemia. It accounted for 275 of 5578 cases in Egypt, 16 of 455 cases in Tanzania and 17 of 653 cases in Ethiopia (Rubach *et al.,* 2013).Brucellosis was also indicated to be a main source of fever whose origin was unknown among children in developing countries, accounting for 97 of 989 cases (Rubach *et al.,* 2013).

In Kenya, brucellosis was first reported in 1916 with the first case confirmed in the laboratory in 1931(Njeru *et al.,* 2016).Since its first reporting, brucellosis studies in both animals and humans have been conducted in various regions of the country. However, the disease burden has not been easy to estimate due to poor reporting. Brucellosis was gazetted as a notifiable disease in the Kenyan laws (Legal notice No. 68), under the animal diseases Act Cap. 364 (Njeru *et al.,* 2016). The gazzetement has greatly enhanced reporting of the disease.

Various Brucella species have been isolated from different wild and domestic animal species (Oomen, 1976;Muendo *et al.,* 2012). In humans, *B. melitensis* and *B. abortus* have been isolated in patients from different parts of the country (Njeru *et al.,* 2016). The frequency and virulence of *B. melitensis* is, however, reported to be higher in humans than that of *Brucella abortus* (Ducrotoy *et al.,* 2015).

A systematic review of brucellosis in Kenya estimated the national sero-prevalence at 3.0%, (Njeru *et al.,* 2016). High sero-prevalence in humans was seen in five counties namely Kajiado, Marsabit, Turkana, Machakos and Garissa while a low sero-prevalence was reported in Kiambu, Naivasha, Busia and Nairobi counties (Njeru *et al.,* 2016).

Majority of the counties associated with high sero-positivity are inhabited by pastoralists' communities. A strong association between animal and human sero-positivity was indicated in a study conducted in Kiambu and Kajiado. Sero-prevalence in Kiambu was 1.2 in animals and 2.2 in humans, while in Kajiado it was 3.4 in animals and 14.1 in humans (Ogola *et al.,* 2014).

2.1.2 General characteristics of brucella organisms

Brucella organisms are known to adapt to a wide range of environments. They can withstand high humidity and low temperatures and thus can remain viable for months in the environment (Aune *et al.,* 2012). *Brucella abortus* has been shown to survive for six days in urine, six weeks in dust, ten weeks in water and about eight months in humid environment (Capasso, 2002). However, the organism can be destroyed if exposed to high temperatures of about 60 ^{0}C for about 10 minutes(Corbel, 2006).

B. melitensis is mainly known to infect sheep and goats and the infection resemble that of *B. abortus* in cattle (Diaz Aparicio, 2013). The organism can thrive in cold and wet conditions for several months and therefore remain a source of infection to other animals by contaminating the environment (Aune *et al.,* 2012; Diaz Aparicio, 2013). It causes latent infection and the infected animals continue shedding the bacteria to the environment as they are silent carriers(Diaz Aparicio, 2013).

B. suis is commonly associated with infection in porcine. The organism can survive desiccation and freezing temperatures but are easily destroyed by high temperatures (Diaz Aparicio, 2013). *Brucella suis* can infect other domestic species especially those in

close contact with infected pigs. It has been isolated in dogs, cattle and wild boar (Norton and Thomas, 1979; Bergagna *et al.*, 2009; It also causes infection in man, with biovars 1 and 3 being highly pathogenic while biovar 2 is linked to immuno-compromised persons (Diaz Aparicio, 2013).

2.1.3 Transmission in man

Nearly all brucellosis cases in man have their origin from animals (Tzaneva *et al.*, 2009). In the infected animals, the organisms localize and multiply in the reproductive system and are excreted in large numbers in the uterine fluids and birth products(Diaz Aparicio, 2013). These serve as a source for infection in man (Mangen *et al.*, 2002). The organism is also present in other organs such as the liver, kidney, spleen, udder and muscles(Corbel, 2006). Transmission is mainly by ingestion of infected material or by direct skin contact with contaminated material. Man contracts the infection following consumption of contaminated animal products e.g. unpasteurized milk and raw meat and blood from infected animals (Corbel, 2006). Brucellosis is thus considered a health hazard to people involved with animals at various levels (Capasso, 2002).

Though *Brucella* organisms can be destroyed at high temperatures, undercooked meat especially from goats has been incriminated in causing infection in man (Omer *et al.*,2000). In some countries, organs like kidney and liver are eaten raw and this increases the risk of consumers to contract the disease (Mfinanga *et al.*, 2003; John *et al.*, 2010).Similarly, some cultures consider consumption of fresh blood either alone or mixed with raw milk as a way of life (Corbel, 2006; Regassa *et al.*, 2009). This presents a

potential health hazard to the consumers(John *et al.,* 2010). However, consumption of contaminated dairy products is considered the main cause of infection in man living in the rural areas (Mendoza-Nunez *et al.,* 2008).

Occupational practices like handling of aborted materials or live foetuses from infected animals also exposes man to the infection(John *et al.,* 2010; Tumwine, et al., 2015).Direct contact with tissues or blood from infected animals can introduce the bacteria to man through broken skin (Zhen *et al., 2*013). This is common among the butchers, flayers and the people working in meat processing plants. People working in laboratories and dealing with bacterial cultures are more prone to brucellosis infection by inhalation (Traxler *et al.,*2013). Accidental inoculation with live vaccine such as *Brucella abortus* is also a possible source of infection. This is common among the people working in the laboratories or the animal health practitioners involved with vaccinations (Traxler *et al.,* 2013; Kutlu *et al.,* 2014).

People living in close proximity with animals like the pastoralists have higher risk of infection(John *et al.,* 2010). In the pastoralist communities, people tend to share common water points with animals. The infected animals may contaminate the water sources e.g. earth dams and water pans. The people consuming such water without first treating it stand a risk of contracting the infection. The children that adopt and play with newborn kids and lambs (Corbel, 2006), are also at risk of contracting brucellosis.

Various routes of inter-person transmission of brucellosis have been described, though rare. These include: sexual transmission (Meltzer *et al.,*2010), trans-placental

transmission from mother to child (Mosayebi *et al.*, 2005) and through breast milk (Palanduz *et al.*, 2000). Transmission through blood donation and tissue transplantation is also a potential route with bone marrow transfer considered of higher risk (Palanduz *et al.*, 2000; Corbel, 2006). Figure 2.1 shows the different pathways through which man can get infected with brucellosis.

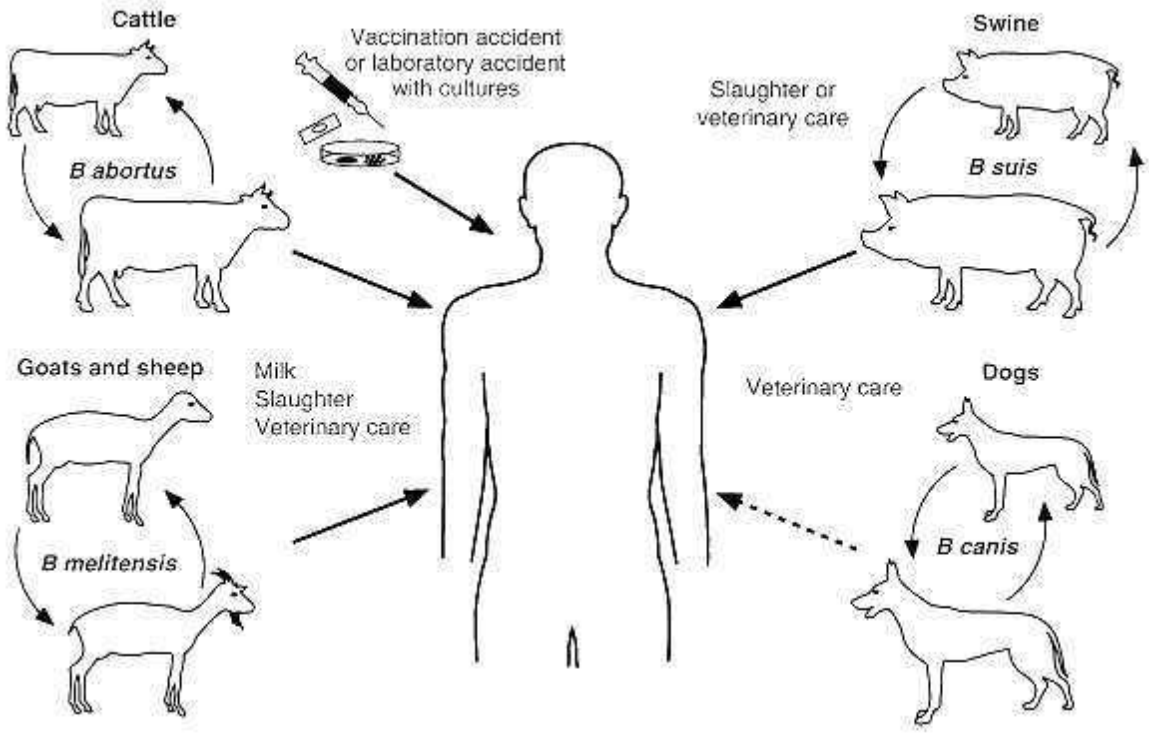


Figure 2.1: Pathways for transmission of brucellosis to humans.

(**Source**: Robinson, 2003)

2.1.4 Transmission in animals

Brucellosis is considered a herd disease. Infection in the herd is associated with introduction of asymptomatic chronically infected animal (Kiambi, 2012). The bacteria localize and multiply in the reproductive system causing placentitis and abortions in the female animals or epididymitis and orchitis in the males (Corbel, 2006). Such animals serve as reservoirs and shed the bacteria in the environment. If such animals are used for breeding, there is a likelihood of sexual transmission of the disease to other animals (Corbel, 2006). In the pastoralists' communities, sharing of the breeding bulls is a common practice and this can enhance transmission of brucellosis between farms. Artificial insemination using semen from infected breeding bulls is also an important factor in the transmission of bovine brucellosis (Corbel, 2006). The animals that conceive and are infected often experience abortion and may later have delayed infertility while others become permanently infertile (Diaz Aparicio, 2013).

Transmission in animals mainly occurs through contact with aborted foetuses or by consumption of contaminated pasture sources(Corbel, 2006).Vertical transmission *in-utero* from infected mothers to the foetus or during parturition may occur though it is rare (Diaz Aparicio, 2013). New born healthy calves may be infected by consuming colostrum or milk from infected animals, especially where pooled colostrum is used (Corbel, 2006; Diaz Aparicio, 2013).

2.1.5 Brucellosis in man

Brucellosis in man manifests in various forms. It may present as an acute or sub-febrile illness or may be of chronic form. The incubation period ranges from three days to over six months (Corbel, 2006). The acute form is characterised by chills, intermittent fever, sweating, fatigue and enlarged lymph glands (Galińska and Zagórski, 2013). In the chronic form, the symptoms gradually set in and include fatigue, muscle pain, backache, constipation, weight loss, depression, sexual impotence etc.(Cutler *et al.,* 2005; Galińska and Zagórski, 2013). These signs are not pathognomonic for they are similar to those of other febrile diseases in man. Due to its nature of continuous intermittent fever, the disease is also referred to as 'undulant fever'. Being a multi-systemic disease, brucellosis manifests various signs in other body systems. Involvement of osteo-articular, cardiovascular, respiratory and central nervous system has been reported (Khorvash et al., 2007; UluKilic *et al.,* 2013; Erdem *et al.,* 2014). The disease has also been associated with musculo-skeletal and uro-genital complications (Cesur *et al.,* 2003;Akinci *et al.,* 2006). In pregnant mothers the disease may cause spontaneous abortions especially in the first and second trimester (Khan *et al.,* 2001; Peker *et al.,* 2011). Brucellosis in man is occasionally associated with endo-carditis which is a highly fatal condition. Most of the deaths resulting from brucellosis have been linked to endo-carditis (Altekin *et al.,* 2011; Obrenovic-Kircanski *et al.,* 2012).

2.1.6 Brucellosis in animals

Brucellosis is a multi species disease with high rate of cross infections between species. Most *brucella* organisms localize in the reproductive system causing various signs.

Orchitis, epididymitis and seminal vesiculitis occur in males while placentitis occurs in females(Diaz Aparicio, 2013). Though most cases are characterised by still births, retained placenta and storm abortions, the latter is rare in some areas (Corbel, 2006). Other signs include low milk yield, osteo-articular involvement, irregular oestrus, and weak newborns (Xavier *et al.*, 2009).Retained after birth often leads to secondary metritis which subsequently causes temporary infertility and in some animals there is permanent sterility(Diaz Aparicio, 2013).Inflammation of the placenta is associated with most of the abortions (Diaz Aparicio, 2013). Approximately 80% of the animals abort once after contracting the infection, with subsequent pregnancies being asymptomatic (Xavier *et al.*, 2009; Diaz Aparicio, 2013). However, some may bring forth weak newborns that die a few days later. The infected females shed the bacteria through foetal and uterine fluids and in milk which serve as a source of infection to man(Corbel, 2006).

2.1.7 Diagnosis of brucellosis

Much effort has been put towards diagnosis of brucellosis both in humans and animals. This has, however, not been easy as it is complicated by a number of factors. The disease presents in various forms and the incubation period varies greatly from days to months (Corbel, 2006). The symptoms exhibited in the acute form of brucellosis are common to a variety of its differentials (Godfroid *et al.,* 2010)This makes diagnosis by clinical manifestations very unreliable thus application of laboratory testing is vital for final confirmatory diagnosis(Ekaterina *et al.,* 2013).

Various serological, bacteriological as well as molecular methods have been used in the diagnosis of brucellosis (Godfroid *et al.,* 2010; Ekaterina *et al.,* 2013). Serological methods are preferred since detection of *Brucella* organisms by culture has occasionally proved unsuccessful (Ulu-Kilic *et al.,* 2013). This is because proper choice of the diagnostic method to use is determined by prevailing brucellosis situation in the area (Godfroid *et al.,* 2010). The ‘’gold standard’’ for brucellosis diagnosis is detection of the organism through culture, which is a very laborious procedure (Nielsen and Yu 2010; Ekaterina *et al.,* 2013).*Brucella* organisms are highly hazardous, and necessitate use of specially equipped laboratories for their isolation.

Several serological tests have over the years been used for diagnosis of brucellosis (Ekaterina *et al.,* 2013). Serum agglutination test (SAT) is highly efficient, though, it is slow and has low sensitivity and specificity (Godfroid *et al.,* 2010). It is not recommended for diagnosis of chronic brucellosis as the results are difficult to interpret or sometimes they are negative (Kiambi, 2012). Complement fixation test (CFT) has also been widely used. Though it is highly specific, it has low sensitivity and is difficult to standardize (Godfroid *et al.,* 2010). Rose Bengal Plate Test (RBPT) is broadly used as a screening test because it is simple to use and highly sensitive. However, it is known to produce false- positive reactors especially in the early stage of incubation or shortly after abortion (Swai and Schoonman, 2010). Enzyme linked immune-sorbent assay (ELISA) tests are more superior and specific, but they have low sensitivity and specificity (Kiambi, 2012).

Fluorescence Polarization Assay (FPA) has been used in brucellosis control and certification in North America and Europe and it measures the degree of polarization of molecules (Godfroid *et al.,* 2010). Though this method is quick to perform, it has shown relatively low sensitivity (Godfroid *et al.,* 2010). Molecular methods based on polymerase chain reaction (PCR) have been developed and are used for identification and typing (Nielsen and Yu, 2010). Real time PCR has particularly been shown to have high sensitivity and specificity and pose low risk to the laboratory workers (Kiambi, 2012). These methods are increasingly becoming very vital tools in brucellosis diagnostics both at the species and biovar levels. However, they are quite expensive and require full validation before they are routinely used in the laboratories (Ekaterina *et al.,* 2013).

2.1.8 Prevention and control of brucellosis

Though brucellosis has been eradicated or controlled to low levels in some developed countries, it remains endemic in most of the low income countries (Ducrotoy *et al.,* 2014). However, there is fear of re-introduction of the disease in the developed countries due to increased international travel (Ducrotoy *et al.,*2014). In most of the developing countries, the disease causes great economic impact and perpetuates poverty (Smits and Cutler, 2004). Control and eradication of brucellosis and other zoonoses depends on various factors. Knowledge of such factors is vital for development of successful control policy (Smits and Cutler, 2004). These factors include: the type of animal production systems, epidemiology of the disease, economic situation of the country, resource availability and government policies supporting disease control among others (Sammartino *et al.,* 2006; Rodolakis, 2014; Liu *et al.,* 2014).

Control of brucellosis in animals involves a number of methods. Whole-herd vaccination coupled to test and slaughter method and application of strong bio-security measures are reported to yield successful control results (Martins *et al.,* 2009; Caetano *et al.*, 2016). However, this requires large financial and human resources and may be impractical to implement especially in the pastoral systems where the disease prevalence and animal mobility are high (Blasco, 2010; Smits and Cutler, 2004). In low-prevalence areas, however, slaughter of entire herd is considered most effective as it limits pathogen excretion and halts subsequent spread of the disease (Gumber *et al.,* 2004). Restriction of animal movement and trade, improved farm sanitation, public education and proper laboratory diagnosis are also key in brucellosis control (Smits and Cutler, 2004). Vaccination increases the proportion of resistant animals in the herds, with subsequent elimination of reactors(Smits and Cutler, 2004). Regular serological testing is therefore important for elimination of reactors in order to minimize pathogen excretion.

The two commonly used vaccines in cattle and shoats are S19 and Rev 1,respectively (Schurig *et al.,* 2002). However, these induce production of antibodies similar to those in real disease and thus can complicate diagnosis (Moriyón *et al.,* 2004). The live vaccines have prolonged immunogenicity and a single dose may confer life-long immunity on the animal(Schurig *et al.,* 2002). However, they are considered unsafe for human use for they may cause abortions as they do in animals (Connolly *et al.,* 2006). *Brucella abortus* S19 is claimed to confer best results when administered in calves and a higher dose increases serological activity and protection (Cheville *et al.,* 1993). However, this vaccine has been implicated to cause epididymitis in males and occasionally chronic infection in calves

seen at slaughter as indicated by Kang'ethe *et al.*,(2007). This could be so because the vaccine produces a prolonged serological response. Vaccination of adult animals with low doses of the vaccine is also thought to be effective and safe (Moriyón *et al.*, 2004). However, none of the vaccines confer 100% protection on the animals.

Most of the control measures can produce immediate cost-effective benefits if they are adapted to the local situations and are supported by the local population (Roth *et al.*, 2003). However, this has not been easy in the low income countries especially in the pastoralist communities where the disease prevalence is high. This is worsened by high animal mobility which makes restriction of animal movement and trade impractical, bearing minimal results. In addition, inadequate financial resources cannot support sustainable test and slaughter for eradication method. Few and inadequately equipped laboratories in these countries lack improved diagnostic techniques necessary to warrant confirmatory test and slaughter method for eradication of brucellosis (Corbel, 2006; M. Ducrotoy *et al.*, 2015).

2.2 Knowledge, practices and perceptions relating to brucellosis

Very few developed countries have managed to control brucellosis to minimal levels (McDermott *et al.*, 2013). In Africa, the disease is endemic in many countries and is reported in all livestock production systems(McDermott and Arimi, 2002). The prevalence and incidence is indicated to be highest in the pastoral systems, and more so in the indigenous breeds (Karimuribo *et al.*, 2007). This is also reflected in the human

population where the prevalence is higher in the pastoralist's communities (Osoro *et al.*,2015). This could be associated with the culture practiced by the pastoralists.

The level of awareness about zoonotic infections among the livestock farmers is thought to significantly contribute to the control of spread of such infections (Lindahl *et al.*, 2015). Lack of awareness on such infections may delay patients from seeking health care in time (Kansiime *et al.*,2014) thus enhancing the spread of the infection among the population. Various studies have shown varying degrees of knowledge about zoonoses especially brucellosis among populations. Literacy level is indicated to have some association with the level of awareness. Some studies have shown higher level of awareness about brucellosis among the educated than the non-educated population (Lindahl *et al.,* 2015).The overall awareness was also reported to be higher among the agro-pastoralist population compared to the pure pastoralists (Kansiime *et al.,* 2014). The awareness levels on brucellosis was also rated higher among the farmers who engaged veterinarians in their animal health problems than in those who did not (Lindahl *et al.,* 2015). A number of studies show that majority of the population have heard about brucellosis, but very small percentage knows how the disease is transmitted and its manifestation both in man and animals (Adesokan *et al.,* 2013; Ljung, 2013).

People engage in a number of practices that may predispose them to zoonotic infections. Some practices involve close contacts with animals which in turn transmit the infectious micro-organisms to man through contact. The pastoralists normally have close interactions with animals as some share common dwellings with animals (Adesokan *et*

al., 2013; Desta, 2016b). Usually, the animal houses are not constructed in a manner that they can protect the animals from adverse weather, but rather enclose then in one place. Due to this, the young kids and lambs are mainly housed in the human houses especially at night to protect them from cold weather.

Consumption of animal products from infected animals also exposes humans to infections. Pastoralists derive most of their nutrition from animals as most of the land they inhabit is unsuitable for crop production. Milk and meat forms the main component of their diet (Greter *et al.,* 2014). To a less extent, animal blood is also consumed either alone or mixed with raw milk. In Ethiopia, the pastoralists were reported to regularly consume raw milk and liver (Desta, 2015; Desta, 2016a) and this predisposes them to brucellosis infection.

Poor management practices applied in animal husbandry can also predispose humans to infections (Melorose *et al.,* 2015; Desta, 2016a). A number of studies indicate that majority of the people use no protective gear while assisting animals in deliveries or when handling aborted materials (Lindahl *et al.,* 2015; Desta, 2016a). Most of the people also do not isolate the sick from the healthy animals. In this case, the aborting animals are retained together with the healthy ones and they continue shedding infected uterine fluids contaminating the environment. This enhances the rate of infection among the animals which subsequently is passed on to humans. Most of the farmers and especially the pastoralists practice mixed animal stocking where they stock cattle, sheep and goats. This poses a risk of cross infection as the brucella species are multi-host. When *B. melitensis*

establishes itself in cattle, it poses greater health risk. Though it is associated with few abortion cases, the infection in the udder leads to shedding of large quantities of bacteria contaminating the environment(Diaz Aparicio, 2013). This poses a great health hazard to humans as *Brucella melitensis* is known to be highly pathogenic to man (Ducrotoy *et al.,* 2015).

The uncontrolled livestock movement along with common grazing and watering points for the livestock increases the spread of brucellosis in the livestock population (Smits, 2013). The spread is also enhanced by the interaction between domestic and wild animals which is a common occurrence in the pastoral communities (Gomo *et al.,* 2012; Godfroid *et al.,* 2013).

2.3 Risk assessment for exposure to brucellosis

For effective control of brucellosis, there is need to conduct a risk assessment for exposure in order to determine the possibility of an adverse effect occurring in a population due to presence of the hazardous agents. The assessment process involves four main stages including: hazard identification, exposure assessment, consequence assessment and risk characterization and estimation (WHO & FAO, 2008). This section of the review considers risk assessment for exposure to brucellosis based on the four criteria using information from literature review.

Hazard identification

This entails detection of any biological, chemical or physical agents present in a particular food and which has the ability to cause adverse health effects (Lammerding and Fazil, 2000).

Based on antigenic characteristics and primary hosts, six species of genus brucella have been identified, namely, *B. abortus, B. melitensis, B. suis, B. ovis B. canis* and *B. neotomae* (Winchell *et al.,* 2010; Mohamed *et al.,* 2015). However, four additional new species have also been identified which include: *B. ceti, B. pinnipedialis, B. microti* and *B. inopinata* (Winchell *et al.,* 2010). Out of the ten species, those attributed to cause the highest impact on domestic productivity and human health are *B. abortus*, *B. melitensis* and *B. suis* (Godfroid *et al.,* 2011; Diaz Aparicio, 2013). *B. abortus* and *B. melitensis* have been isolated in different species in Kenya including wild and domestic animals and humans (Oomen, 1976; Muendo *et al.,* 2012). The frequency of *B. melitensis*, hence its virulence, is reported to be higher in humans compared to that of *B. abortus* (Ducrotoy *et al.,* 2015).

Hazard characterization

This is the second step and refers to the qualitative or quantitative evaluation of the nature of effects associated with biological, chemical or physical agents present in the food (WHO and FAO, 2003). It concerns the particular agents or species involved e.g., micro-organism and its interaction with the host, its virulence and pathogenecity. The three brucella species associated with the highest impact on domestic productivity are *B.*

abortus, B. melitensis and *B. suis* (Godfroid *et al.*, 2011). Though these preferentially affect cattle, sheep/goats and pigs, respectively, there can be cross infection in mixed husbandry systems or where there is animal wildlife interface (Godfroid *et al.*, 2013).

Brucellosis is transmitted to man through ingestion, inhalation or direct contact with contaminated material (Mohamed *et al.*, 2015). The main species incriminated to cause the disease in man are *Brucella abortus, Brucella melitensis, Brucella suis* and some *biovars of Brucella canis* (Atluri *et al.*, 2011). *Brucella melitensis* is, however, reported to have the highest frequency and virulence in humans compared to other *Brucella species*(Ducrotoy *et al.*, 2015).

Exposure assessment

This describes the biological pathways vital for exposure of either animals or humans to the pathogenic agent from a risk source, and estimating the probability of exposure taking place under specified conditions (WHO and FAO, 2003). Factors such as: the amount of pathogen in the exposure, duration of exposure, routes of exposure, animals or human characteristics play an important role in estimating the probability of exposure.

Infection in man occurs following exposure to materials or products from infected animals. The exposure may be through direct contact, ingestion or inhalation of infected materials (Ogola *et al.*, 2014). Consumption of unpasteurised milk and other dairy products from infected animals plays a key role in transmitting brucellosis to man (Makita *et al.*, 2011). Consumption of raw or undercooked meat and fresh blood has been incriminated as a source of infection to man (John *et al.*, 2010; Adesokan *et al.*, 2013).

Occupational practices like handling aborted materials or live foetuses from infected animals is another way of exposing man to the infection (Aworh *et al.,* 2013). Direct contact with tissues or blood from infected animals can introduce the bacteria to man through broken skin (Corbel, 2006). In a study conducted in Narok women were shown to participate in assisting the new born calves through mouth to mouth resuscitation (Onono *et al.,* 2013).This could also expose them to brucellosis infection through direct contact.

People working in the laboratories dealing with bacterial cultures and those involved in field animal vaccinations are prone to brucellosis infection by inhalation or accidental inoculation with live vaccine(Ashford *et al.,* 2004). People living in close proximity with animals like the pastoralists have higher risk of infection. As people work on the contaminated environment, e.g. gathering and collecting manure, they may get exposed through inhalation (Corbel, 2006).

Risk characterisation and estimation is the last step in risk assessment. It is achieved by combining and critically analysing the results obtained from the other three steps to finally express the overall conclusion about the potential risk to human population. Recent studies have shown that *Brucella abortus* and *Brucella melitensis* have been isolated in cattle and humans in various regions of the country (Njeru *et al.,* 2016). Data on the disease prevalence has indicated higher prevalence in the pastoral production systems compared to the settled systems (Kadohira *et al.,* 1997; Osoro *et al.,* 2015). Various routes are implicated in transmission of brucellosis from animals to humans.

Various animal husbandry and socio-cultural practices have also been associated with enhancing brucellosis spread among populations. Some of the practices involve close contact between humans and animals, consumption of raw animal products and handling of reproductive tract contents without protective gear. These practices pose great risk of infection to the humans involved.

A number of brucellosis studies done in the country have focused on identifying the various risk factors contributing to the spread of brucellosis in both man and livestock (Njeru *et al.,* 2016). Most of the risk factors identified in various studies are associated with the cultural practices especially by the pastoral communities (Regassa *et al.,* 2009). However, little has been done in evaluating the contribution of these risk practices in exposing the household members to brucellosis.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Study area

The study was conducted in Kajiado County which is a good representative of pastoralists' communities. Kajiado County lies in the former Rift Valley Province in Kenya. It borders Narok and Kiambu Counties to the West, Nairobi and Machakos Counties to the North, Makueni and Taita Taveta Counties to the East and Tanzania to the South (Figure 3.1).

The County covers an area of 21,900 Km^2 with a population of 687,312 persons (GoKASDSP). This converts to a human population density of 31 persons per Km^2. Administratively, it is divided into five constituencies namely Kajiado North, Kajiado Central, Kajiado South, Kajiado West and Kajiado East (GoK-ASDSP).Figure 3.1 shows the location of Kajiado County in the map of Kenya.

The county is designated as semi-arid and receives an annual rainfall ranging between 500mm- 1250mm, with average annual temperatures of 18.9^0C. The original inhabitants of the county are the Maasai community who are pastoralists and keep large herds of cattle, sheep and goats. However, due to urbanization there has been increased immigration into the county by people from other communities. This has resulted in intensive livestock and crop farming especially around the major towns. Nevertheless, livestock rearing still plays a key role in contributing to the county's economy.

The size of arable land is 3468.4 km^2, with the average land holding size being approximately 9 hectares on small scale and 70 hectares on large scale (GoK-ASDSP, 2013).Most of the farmers keep livestock and a small population undertake subsistence farming especially in Kajiado East, Kajiado South and Kajiado North constituencies. The county livestock populations as per the 2009 census are 411,840 cattle, 718,950 sheep and700, 685goats (Kenya open data).This translates to approximately 0.60 cattle, 1.05 sheep and 1.02 goats per person respectively.

The County has two main types of livestock production systems: livestock farming which is mainly practiced in the interior rural area. This is referred as ‘rural pastoralism system’ in this study. The other is the mixed livestock and crop farming mainly practiced around the towns. In this study, this system is referred to as ’peri-urban agro-pastoralism system’.

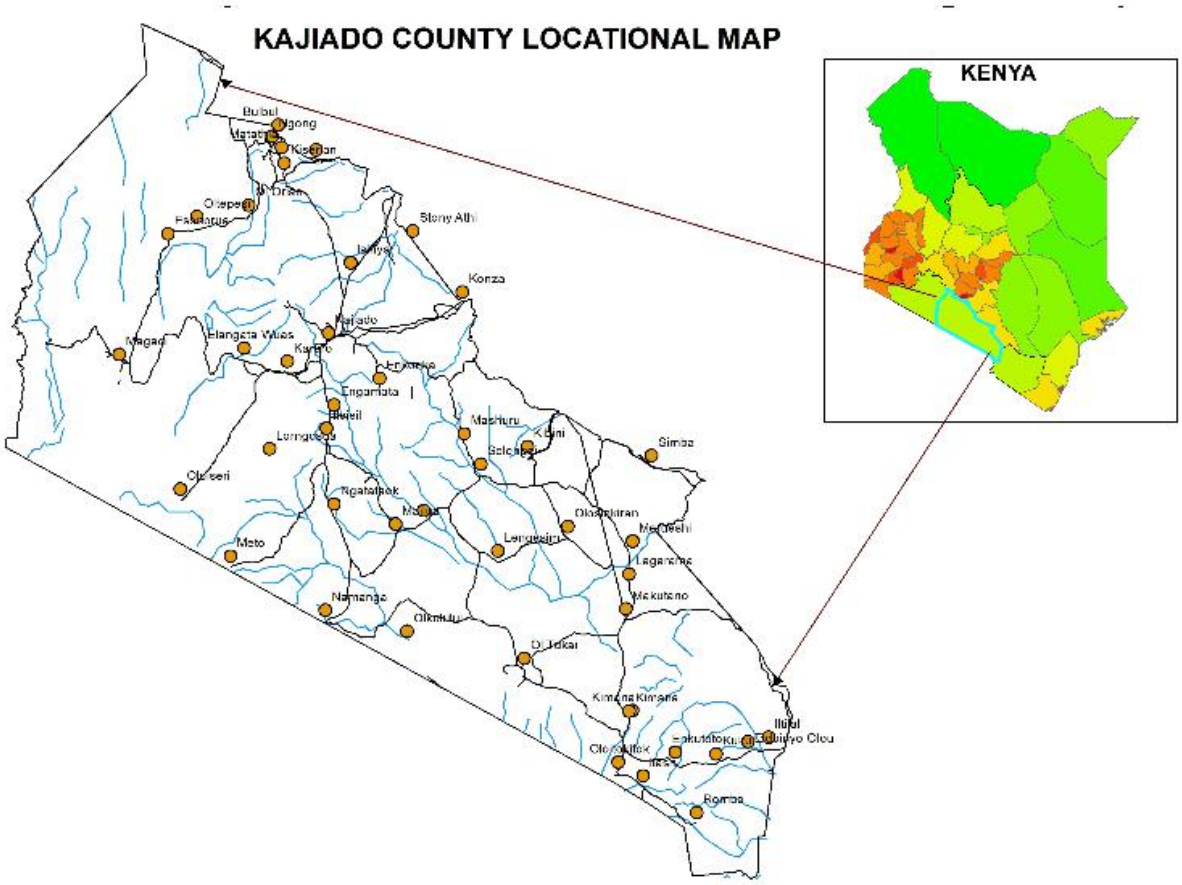


Figure 3.1: Map of Kenya showing the location of Kajiado County and a map of Kajiado County showing the administrative units

Source: http://reliefweb.int/report/kenya

3.2 Study design and selection of study participants

The field data collection was done between the months of July and September, 2015. In order to conduct the study in the county, authority was obtained from the County Director of Veterinary Services. With the help of the county veterinary staff assigned, the county was categorised into two production systems. The first category was 'rural pastoralism system' mainly practiced in the interior rural areas and characterised by keeping large herds of cattle, sheep and goats. These are reared in large tracks of land and there are communal grazing and watering areas. The second one was 'peri-urban agro-pastoralism system', practiced around the major towns. It is characterised by mixed livestock and crop farming. The land and herd size is quite small compared to rural pastoralism system. There is minimal communal land utilization and sharing of communal watering points.

With this consideration, two sub-counties were purposively selected to represent these production systems. Isinya sub-county in Kajiado East constituency was selected to represent the agro-pastoralism system and Kajiado Central constituency to represent the rural pastoralism systems. Two divisions within the selected sub-counties considered good representative of the target population were purposively selected. In Kajiado Central sub-county, Matapato North and Matapato South divisions were selected, while Kitengela and Kaputiei North divisions were selected in Isinya Sub-County.

A local village elder was identified from each of the selected divisions to aid in getting participants for focus group discussions (FGDs). With the help of the village elders and the veterinary staff, two focus groups were formed from each division. A total of eight

(8) focus groups, each comprising between 7-11 members, were formed from the two sub-counties. The group members were engaged in focus group discussions, facilitated by the lead researcher who was assisted by the assigned county veterinary staff. In every area, a local who understands the Maasai language was sought to aid in translation. From Kitengela Division, the discussions were held in Sholinke and Kitengela areas, while in Kaputiei North Division, they were held in Olturoto and Kisaju areas. From Matapato North in Kajiado Central, the discussions were held in Lorngosua and Ilpatimaro areas while in Matapato South, they were held in Meto and Kumpa areas.

With the help of the local veterinary personnel and village elder, twelve participants were identified from each targeted area and were invited for the discussions. However, not all the participants turned up for the meetings in every group. The participants (farmers) selected for the focus group discussions were all adults from different villages, and of different ages, occupation and education levels. Six groups comprised both male and female participants and two groups comprised each gender separately. Semi-structured questionnaires were used to guide the participants in their discussions and aid in data collection (Appendix 1).

The research data collected touched on various issues and included the following: (i) a list of livestock diseases (cattle, sheep and goats) perceived to have great impact on livestock production and household income, in order of their importance; (ii) impact of the listed diseases on various production parameters; (iii) the participants' knowledge about brucellosis in animals and humans and the associated symptoms in animals; (iv) the

factors contributing to spread of brucellosis in man; (v) disease management in animals and (vi) Participants' perceptions on impact of human brucellosis. The questions and the participatory techniques were pre-tested in a sample group in Kitengela area and necessary adjustments made. The time taken per workshop varied between 1 to 2 hours with an average of about one hour and 30 minutes.

3.3 Data collection

Primary data was obtained through focus group discussions and researcher's own observations. Secondary data on the other hand, was obtained by a review of surveillance data from previous studies. Focus group discussion (FGD) is a research tool that employs small- group interviews to discuss a specified topic with the aim of obtaining some qualitative data (Wong P, 2008). The groups that participated comprised membership of between 7-11 members. This complies with the group composition description of 6-12 participants as described by Dilshad and Latif, (2013). Flip charts, note books, pens and a camera were used as tools for data collection.

Because of the vastness of the area and the availability of the participants, two group discussions were held in a day. Between the discussions, data were reconciled for each group to ensure validity. The objectives of the study were explained to the participants and any questions from them answered. The participants were encouraged to have free participation and give any useful information they had regarding the topic being discussed. They were assured that the information they gave was to be handled with confidentiality and only used for research purposes. All the members gave their consent

by filling in their demographic data in the participants list form (Appendix 2) and signing the attendants form (Appendix 3). Plate 3.1 shows a focus group in session in Kumpa Division, Kajiado Central sub-county.

Plate 3.1: A focus group in session in Kumpa Division, Kajiado Central sub-county

3.3.1 Knowledge, practices and perceptions on brucellosis

Various published participatory methods and tools were employed in order to gather the required information. Listing method was used where the participants were asked to list all the livestock diseases that greatly impact on production and household income, as described by Jibat *et al.,* (2013). The participants gave the local names of the diseases and the associated symptoms. In consultation with the local veterinarian, the scientific name

of each mentioned disease was identified and listed. The list was not specific for each animal species but rather all the important livestock diseases. This list was useful in determining the scores and ranks of livestock diseases according to their perceived impacts by the locals.

Pair wise ranking method was used as described by Catley *et al.,* (2012). In every group, all the diseases considered important were listed. The participants were asked to discuss and compare the effects of each disease on livelihood and animal productivity. By comparing the effects of every two diseases at a time, the one perceived to have greater impact was ranked top. This resulted in a list of livestock diseases in order of their perceived importance for every group.

Disease matrix scoring method was applied as described by CAHN, (2012) The diseases listed as per the pair-wise ranking were placed on the x-axis. The production parameters being evaluated (milk yield, abortion, morbidity and mortality) were also placed on the y-axis. The disease impact on the production parameters was categorised as high, medium or low as perceived by the participants. A value of 3 stones representing high impact, 2 stones for medium impact and 1 stone for low impact was used. This information was clearly explained to the participants before they participated. They were then given ten stones to allocate them among the production parameter depending on the perceived disease impact on each parameter. Each disease was evaluated at a time and the total score for all production parameters obtained. The results obtained were compared with

those of the pair-wise ranking and the disease with the highest score for all the production parameters was considered as the most important and was ranked top.

Proportional piling method was used to estimate the impact of each listed disease on various production parameters as described by Catley *et al.,* (2014). The participants were given 10 bean seeds to distribute among the production parameters as per the perceived disease impact. The parameter considered highly affected when the disease strikes was allocated more seeds and *vice-versa*. Each disease was considered at a time and its perceived impact on specific production parameter (milk yield, abortion, morbidity and mortality) recorded. An overall rating was done for all the diseases indicating their impact on various production parameters.

Probing method was also employed as described by Berry, (1999). It was applied in cases where the facilitator felt a need for clarity or more insight in a question. It was also done where the information given was considered inadequate with the aim to increase the quality and quantity of the data being obtained.

3.3.2 Identification of potential exposure factors

Regarding exposure to brucellosis, an assessment of the participants' knowledge on transmission of brucellosis from animals to man was done. The participants were asked to mention and list the ways by which man can acquire brucellosis. This included various factors that influence brucellosis transmission from animals to humans. The factors identified were useful in exposure assessment and estimation of risk of brucellosis infection among the population under study.

3.4 Data management and analysis

Data on scores for the various parameters which were obtained from the focus group discussions were entered into MS excel while the analysis was done using Genstat statistical programme. Both descriptive and inferential statistics were used in the analysis. Descriptive statistics methods were used to show measures of central tendency such as means and median. The results obtained were presented in tables, graphs or charts depending on the type of results.

Inferential statistics was applied in ranking and matrix scoring questions giving the z-scores. The data obtained were used to measure the level of agreement amongst groups of the FGDs using Kendall's coefficient of concordance as described by Catley, (2006). The level of agreement was classified as 'weak' ($W < 0.26$, $p > 0.05$), 'moderate' (W = 0.26-0.38, $p < 0.05$) and 'strong' ($W > 0.38$, $p < 0.01$). Kruskal Wallis One-way Anova was also used to test whether the average scores obtained for each disease as ranked by participants were significantly different from zero. The results are as shown in appendix 4.

The Kendall's coefficient of concordance formula used was by DISA, (2016).

$$W = \frac{12R}{m^2(k^3 - k)}$$

Where,

W = is the Kendall's coefficient of concordance

R = is the sum of squared deviations

m = refer to the raters (groups)

k = are the subjects being rated (diseases).

3.5 Risk assessment for exposure to brucellosis

The risk assessment was done according to the CODEX Alimentarius risk assessment framework, which defines risk assessment as a scientifically based process comprising four inter-related steps. These steps include hazard identification, hazard characterization, exposure assessment and risk estimation(WHO & FAO, 2008). Figure 3.1 shows the components of risk assessment as indicated by codex Alimentarius Commission.

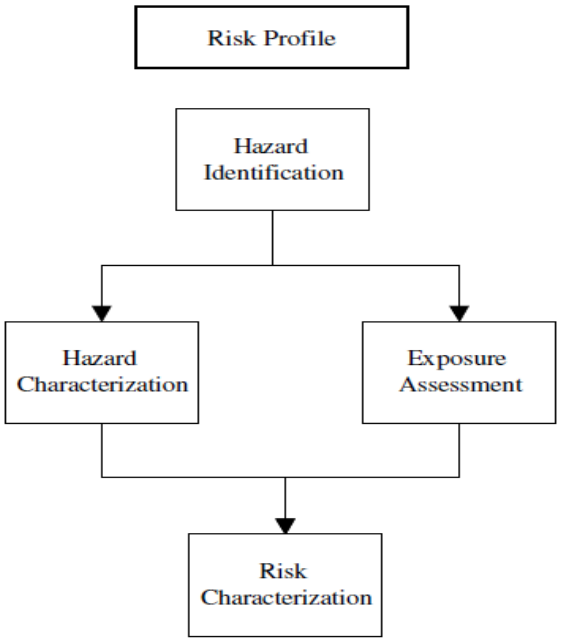


Figure 3.3: Components of a Risk Assessment:

Source:(WHO& FAO, 2008)

This framework defines a hazard as a biological, chemical or physical agent or a condition of food which has the potential to cause an adverse health effect. Hazard identification therefore denotes detection of any biological, chemical or physical agent present in a particular food and which has the ability to cause adverse health effects (WHO-FAO, 2009). This was achieved by reviewing previous studies on brucellosis in various areas especially in the county of study.

The second step is hazard characterization which refers to the qualitative or quantitative evaluation of the nature of effects associated with biological, chemical or physical agents present in the food (WHO-FAO, 2009). It concerns the particular agent or species involved, e.g., micro-organism and its interaction with the host, its virulence and pathogenecity. This was achieved by reviewing past studies and literature to evaluate the various variants of brucellosis isolated in different places and their pathogenecity.

The third step is exposure assessment. This refers to qualitative and/or quantitative estimation of the possible intake of biological, chemical and physical agents through food or exposures from other relevant sources (WHO-FAO, 2009) . It describes the biological pathways vital for exposure of either animals or humans to the pathogenic agent from a risk source, and estimating the probability of exposure taking place under specified conditions (OIE, 2010). Factors like the amount of pathogen in the exposure, duration of exposure, routes of exposure, animals or human characteristics, etc, plays an important role in estimating the probability of exposure. Data about the various path-ways was obtained by literature review. In this study, the diverse routes of exposure involved in

disease transmission from animals to man were evaluated. The participants were asked to name the possible pathways they perceived to contribute to the transmission of brucellosis to man. Figure 3.2 shows a conceptual framework for pathways risk assessment.

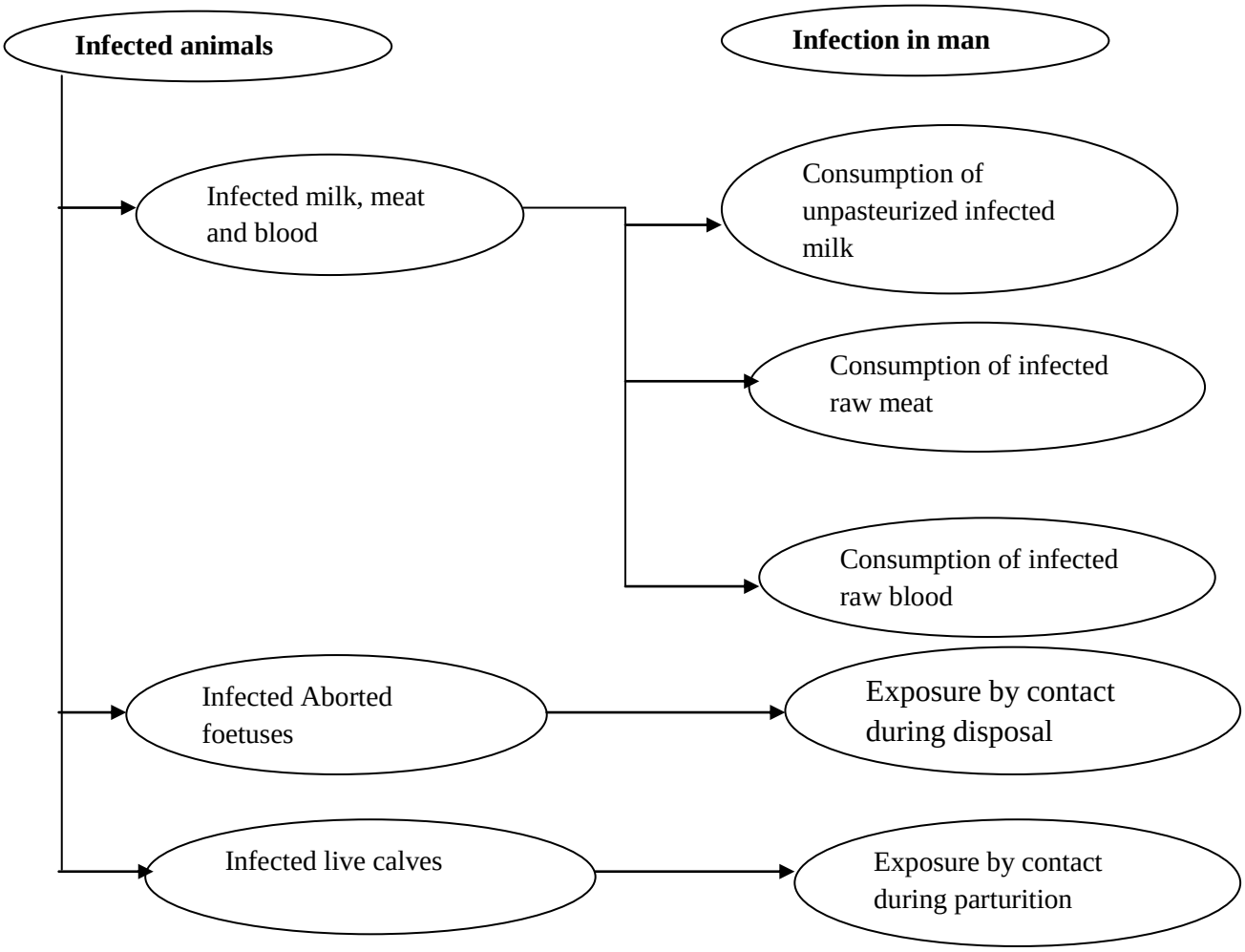


Figure 3.2: Conceptual framework for pathways in risk assessment

Risk characterization and estimation is the last step in risk assessment. This was achieved by combining the results obtained from the other three steps. These results were critically analyzed and all combined to finally express the overall conclusion about the potential risk to human population. Through literature review, data were obtained regarding brucellosis situation in the country. The various brucella species isolated in different animal species in the country were also identified through literature review. Various practices likely to enhance spread of the disease were also evaluated, and the associated potential risk of exposure assessed. Evaluation of all these factors aided in estimating the risk of exposure of the pastoralists' population to brucellosis infection in the current study.

CHAPTER FOUR

4 RESULTS

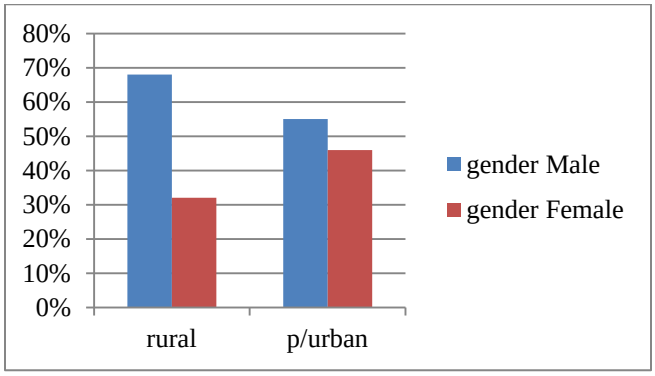
4.1 Respondent's demographics

In the rural pastoralists' category, a total of 38 respondents participated. Out of this, 32% were females and 68%, were males (Table 4.1). About 47% of the participants were between 25-30 years of age, 34% were between 31-40 years and 19% were above 40 years. With regard to the level of education, 45% of the respondents had attained primary school education, 21% had gone to secondary school, and 3% had tertiary education while 31% had no formal education. The peri-urban group of agro-pastoralists attracted 33 participants, 46% of whom were females and 54% males (Table 4.1). About 15 % were between 25-30 years of age, 52% between 31-40 years and 33% above 40 years. All the participants had at least attained some level of education; 18% of respondents had primary school education, 49 % had secondary school education and 33 % had tertiary education (Table 4.1).This therefore shows that the peri-urban participants were better educated than the rural participants based on the number of participants with higher education.

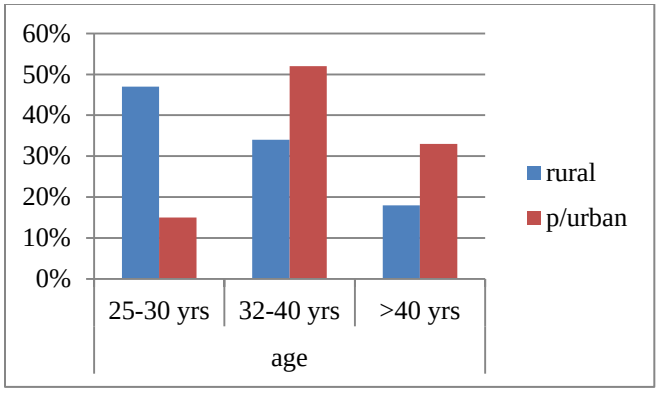
Table 4-1: Demographic characteristic of respondents in a survey conducted in rural and peri-urban regions of Kajiado County, 2015

Variable	Level	Rural pastoralist group; 'n' and proportion (%)	Peri-urban pastoralist group; 'n' and proportion (%)
Gender	Male	26 (68%)	18 (55%)
	Female	12 (32%)	15 (46%)
Age	25-30 yrs	18 (47%)	5 (15%)
	32-40 yrs	13 (34%)	17 (52%)
	>40 yrs	7 (18%)	11 (33%)
Education	No formal	12 (32%)	0 (0%)
	Primary	17 (45%)	6 (18%)
	Secondary	8 (21%)	16 (49%)
	Tertiary	1 (3%)	11 (33%)

Gender


80%
70%
60%
50%
40%
30%
20%
10%
0%
rural
p/urban
gender Male
gender Female

Age


60%
50%
40%
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25-30 yrs
32-40 yrs
>40 yrs
age
rural
p/urban

Education

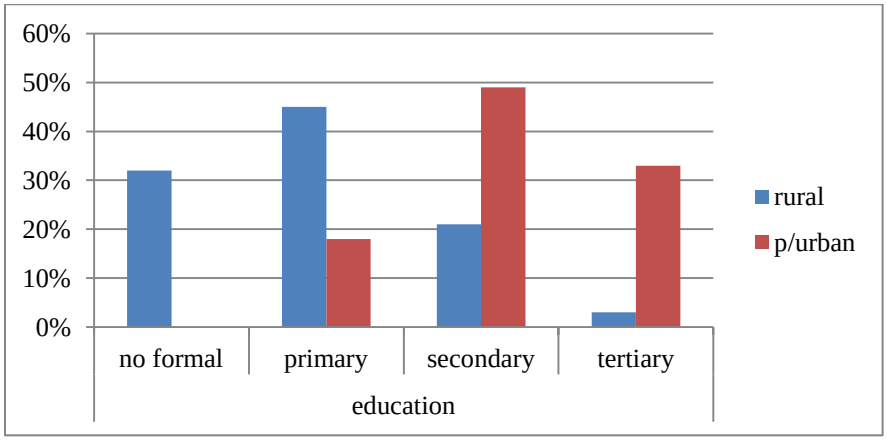

Figure 4.1: Graphic presentation of the participants' demographics

4.1 Knowledge, practices and perceptions of diseases

4.1.1 Common livestock diseases affecting herds in Kajiado County

A total of eleven diseases were listed from all the eight groups. There were more similarities in diseases suggested by the rural pastoralists groups compared to those by peri-urban groups. Surprisingly, only two of the peri-urban groups mentioned brucellosis among livestock diseases and none from the rural pastoralists groups. By pair-wise ranking, all the groups ranked the diseases according to their perceived importance. The overall disease ranking for all the groups was done to get the median, mean rank and the Z-score.

Contagious caprine pleura pneumonia, LSD and FMD were the diseases attributed to the greatest impact on the production parameters as they had a Z-score above 1.2 (Table 4.2). Among all the listed diseases, those with zoonotic potential were ranked quite low.

Brucellosis, which was the main focus in this study, was ranked seventh with a Z-score of –0.99 and anthrax fifth with a Z-score of -0.63.

Table 4-2*:* Rank order for the diseases which affected flocks/herds according to various groups of pastoralists in Kajiado County

Diseases	**Number of groups**	**Median**	**Mean rank**	**Z-score**
CCPP	8	0.40	83.50	4.53
LSD	8	0.13	61.50	1.97
FMD	8	0.18	55.50	1.28
Diarrhoea	8	0	45.50	0.12
Anthrax	8	0	39.00	-0.63
Heart Water	8	0	36.50	-0.93
Brucellosis	8	0	36.00	-0.99
ECF	8	0	36.00	-0.99
Pneumonia	8	0	35.00	-1.10
Eye infection	8	0	30.50	-1.63
PPR	8	0	30.50	-1.63

Key:

FMD: Foot and mouth disease

CCPP: Contagious caprine pleura pneumonia

LSD: Lumpy skin disease

ECF: East coast fever

PPR: Peste des petits ruminants

4.1.2 Agreement on rank order across pastoralists groups

The Kendall's coefficient of concordance method was used to check the level of agreement on rank order for the important diseases across the groups. According to Cartley, (2006), any value for Kendall's Coefficient 'W' below 0.26 is considered weak. In this study, the Kendall's coefficient of concordance 'W' was 0.007, which was weak thus the level of agreement between the various groups with regards to important livestock diseases was low.

4.2.3 Impact of diseases on production parameters

To assess the impact of diseases on production parameters, four key parameters were considered which included milk yield, abortions, morbidity and mortality. The three diseases associated with high mortality were (CCPP), (LSD) and (FMD) (Figure 4.1). Milk yield was affected mainly by FMD, LSD and heart water while abortions were reportedly mostly associated with FMD. Over all, CCPP, FMD and LSD were the three diseases associated with greatest impact on production parameters. These diseases were also reported to be occurring quite frequently in the community. This may contribute to the high ranking as the effects are frequently observed when outbreaks occur.

The two diseases in the list which were supposedly of great zoonotic potential were brucellosis and anthrax (Figure 4.1). Their rating among the listed livestock disease was

quite low. Despite the low ranking, the impact of anthrax on morbidity, mortality and milk yield was relatively high. Brucellosis was associated with high rates of abortions and morbidity with less effect on milk yield. However, no deaths were associated with it. The low ranking of these diseases may be attributed to low frequency of outbreaks in the area compared to the other three top rated diseases.

The farmers usually rate the importance of a disease depending on the losses associated with it. In case of brucellosis, there is hardly any mortality of live animals. The losses associated with abortions and still births have no monetary value attached to it by the farmers. Though it impacts on milk yield, milk is not considered a key economic product for the pastoralist's. In addition, most of the symptoms were associated with chronic form of the disease thus not alarming to the farmer. This together with low level of awareness on the disease could have made the farmers rate it low amongst other diseases.

Table 4.3: Results for disease matrix scoring with regard to the impact of various diseases on livestock production parameters

	% impact of diseases on livestock production parameters			
Diseases	**Milk yield**	**Abortions**	**Morbidity**	**mortality**
FMD	0.20	0.33	0.13	0.18
CCPP	0.07	0.26	0.32	0.27
LSD	0.16	0.09	0.20	0.18
H/water	0.16	0.00	0.05	0.08
ECF	0.12	0.11	0.06	0.05
Diarrhoea	0.12	0.07	0.08	0.05
Pneumonia	0.05	0.00	0.02	0.03
Eye infection	0.03	0.00	0.00	0.06
Brucellosis	0.02	0.02	0.02	0.05
PPR	0.01	0.09	0.03	0.00
Anthrax	0.07	0.02	0.09	0.04

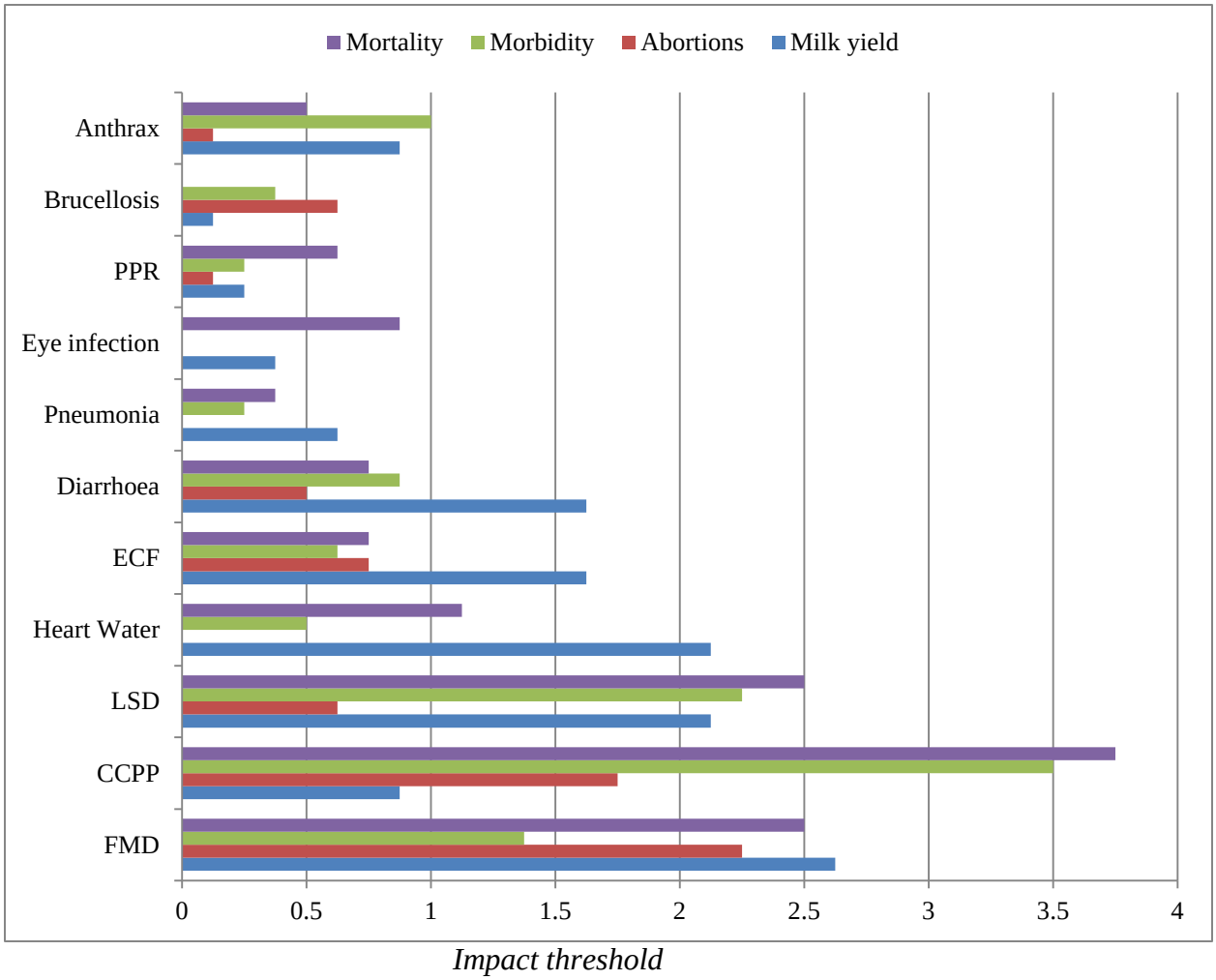

Figure 4.1: **Impact of diseases on production parameters in flocks/herds as perceived by pastoralists in Kajiado County, 2015**

4.1.3 Overall knowledge, practices and perceptions of brucellosis

Apparently, brucellosis (locally referred to by the local community as "*ugonjwa wa maziwa"*-an illness of milk), was not well known as a livestock disease among the pastoralists' communities. It was mentioned by only two of the peri-urban groups and none from the rural pastoralists groups. Only abortion was mentioned as a sign associated with the disease in the affected animals. However, when probed about some signs

associated with the disease in animals such as spontaneous abortions, still births, retained placenta and orchitis, they all acknowledged seeing these signs. Six of the groups, associated these symptoms with sub-clinical foot and mouth disease (FMD) in cattle and contagious caprine pleura-pneumonia (CCPP) in goats. However, all the participants had heard of brucellosis in humans and knew some people diagnosed with the disease.

Regarding transmission of brucellosis from animals to man, the participants suggested un-boiled milk and under cooked meat as possible routes. They said that people diagnosed with brucellosis were prohibited by doctors from consuming milk and meat from the domestic animals. They were also advised to thoroughly boil milk before consuming it. One of the urban groups also suggested that contaminated water could be a source of infection in man. All these fall under the ingestion route. However, none mentioned transmission by direct contact with infected material or by inhalation.

With regard to control and management of infected animals, those that aborted were treated with antibiotics like tetracycline, penicillin and streptomycin. Those with retained after birth were given a solution of ‘’Omo’’- (a powder detergent) mixed with water. All the rural pastoralists groups and two of the peri-urban groups added that sometimes they boiled some herbs and gave the concoction to the affected animals. All these were believed to aid in the expulsion of the retained after birth.

The participants agreed that some of the practices in the community may predispose them to brucellosis. Consumption of unpasteurized milk was commonly practiced among the rural pastoralists. Fresh raw milk and sometimes colostrum was given to young children

as it is believed to enhance immunity. However, the practice was rare among the peri-urban group of pastoralists as some people used processed milk while majority boiled milk before use. Fermenting milk was also common among the rural pastoralists and they didn't boil the milk before fermenting. Instead, they used to add some herbs or charcoal which they considered a form of milk treatment. The practice was rare among the peri-urban population due to inadequate milk availability. Majority of the peri-urban population used to buy already fermented milk (*mala*), commonly sold in the milk outlets or shops though not sure how if it was treated. However, the few in the urban areas who fermented milk at home didn't boil it before fermenting.

When asked whether they used any protective gear like gloves when assisting animals in deliveries, the answer was ''No''. Only in one of the peri-urban groups did some participants say they sometimes used polythene papers when handling aborted foetuses or placenta. Regarding disposal of aborted material, six of the groups reported giving it to dogs. Two of them said that they sometimes threw them into the bush, where most of them could still end up being consumed by the dogs. Two of the peri-urban groups reported that a part from giving to dogs, some of them buried or threw them into pit latrine.

Concerning the cost of treatment for brucellosis in man, all the participants acknowledged that it was quite high compared to other common diseases like malaria and typhoid. This was linked to the long course of treatment for brucellosis. For the severe cases where one has to go for injections for 21 days, the cost of transport was worrying.

This was more severe for the rural pastoralists where the health facilities were far away and accessing the facility was quite expensive. The transport cost in the rural areas ranged between Ksh. 600 to Ksh. 3000, with an average of Ksh. 1650 per visit to the nearest health facility. This was, however, less in the peri-urban groups where it ranged between Ksh. 200 and Ksh. 600 with an average of Ksh. 450 per visit.

They also indicated that most of the health facilities were inadequately equipped especially in the laboratories for satisfactory diagnosis. Some, especially in the rural areas had no laboratories at all. This could have lead to misdiagnosis especially where symptomatic diagnosis is done resulting in wrong treatment. This misdiagnosis consequently could result in the disease being chronic in nature and could also lead to other health problems.

4.2 Risk assessment for exposure to brucellosis

This was done according to the CODEX Alimentarius guidelines (CAC, 2011). Literature review was done to get details on hazard identification. It was clear that brucella pathogen has been isolated from various animal species as well as humans in Kenya (Waghela & Karstad, 1986, Muendo *et al.,* 2012). The pathogen has also been detected in bovine milk from different parts of the country (Kang'ethe *et al.,* 2007). *B. abortus* and *B. melitensis* have been isolated in cattle and humans and *B. suis* in rodents (Njeru *et al.,* 2016).

Various pathways have been associated with transmission of brucellosis from animals to humans. The most common routes are ingestion of infected material, direct skin contact

with infected material and inhalation of contaminated aerosols (Corbel, 2006). The possible routes of exposure to brucellosis were evaluated among the pastoralists in the current studies. The results obtained were as indicated in Appendix5.

4.3.1 Risk ranking assessment

From the data obtained, risk factors such as consumption of unpasteurized milk, raw meat and raw blood and handling reproductive tract contents from infected animals were suggested. A risk ranking assessment was done focusing on the suggested factors. The participants were requested to allocate score for each factor as per the perceived risk. The scoring was as given in Table 4.5.

Table 4-3: Scores associated with each level of risk of contracting Brucellosis by pastoralists in Kajiado County, 2015

RISK SCORE	TYPE OF RISK	OUTCOME
+++++ (5)	High risk	The event occurs very often
++++ (4)	Medium risk	The event occurs regularly
+++ (3)	Low risk	The event is rare but does occur
++ (2)	Very low risk	The event is very rare but cannot be excluded
+ (1)	Negligible risk	The event is so rare that it does not merit to be considered

The risk potential associated with these factors was analysed to finally estimate the risk. The factor considered to have the highest potential of transmitting the hazard (pathogen) to the vulnerable human population was categorized as high risk and *vice versa*. A scale was developed to aid in risk characterization as shown in Table 4.4 and the results are shown in Table 4.5.

Table 4-4: **A scale used in risk characterization of Brucellosis infection by pastoralists in Kajiado County**

Scale	**Risk**
1-4	Negligible
5-8	Very low
9-12	Low
13-16	Medium
17-20	High

Table 4-5: **Scores allocated per risk factor of contracting Brucellosis by pastoralists in Kajiado County, 2015**

Category	Group name	*Unpasteurized milk*	*Raw meat*	*Raw blood*	*Handling birth materials without gloves*
Rural 1	***Lorngosua***	++++	+++	+++	+++++
Peri-urban 1	***Sholinke***	++	+	+	++
Rural 2	***Ilpatimaro***	+++++	++++	++++	+++++
Peri-urban 2	***Kitengela***	++	+	+	++
Rural 3	***Meto***	+++++	++++	++++	+++++
Peri-urban 3	***Olturoto***	+++	+++	++	++++
Rural 4	***Kumpa***	+++++	+++	++++	+++++
Peri-urban 4	***Kisaju***	+++	++	++	+++
Total	***Rural***	19	14	15	20
	Peri-urban	10	7	6	11

The risk factors were ranked according to the level of risk associated with each factor. Handling birth contents without gloves and consumption of unpasteurized milk were associated with high risk of exposure among the rural pastoralists. The pastoralists kept mixed livestock species and had close interactions with them. Brucella organisms, which localize and multiply in the reproductive system, may spread across the species either by

ingestion of contaminated material e.g. pasture, or even by direct contact with infected animals or material. People had a tendency of assisting animals in delivery and handling birth contents without protective gear. This increases their exposure to the pathogen thus enhancing chances of transmission of brucellosis from animals to man.

Raw fresh milk and colostrum were habitually given to young children as they were perceived to enhance immunity. This practice was higher among the rural pastoralist group. Literature indicates that raw milk is one of the common routes of brucella transmission from animals to man (John *et al.,* 2010). There was therefore higher risk of exposure among the children feeding on raw milk in the rural pastoralists group. In the peri-urban group, however, the risk associated with the two factors was low. The peri-urban pastoralists kept fewer animals and the practice of keeping mixed species was low. Some of them also accessed veterinary services thus exposure through handling of infected birth products was lower than in the rural pastoralists group. Most of the people used pasteurized processed milk and most of those who bought unpasteurized milk from milk shops reportedly boiled it before use.

Consumption of Raw meat and blood were associated with medium risk among the rural pastoralists group. Consumption of raw blood was practiced during ceremonies where home slaughter was done. Kidneys and sometimes the liver were also reportedly consumed raw during slaughter. Home slaughter was a common practice among the rural group due to lack of slaughter premises and long distances covered to get to the available slaughter-houses. The risk was, however, also considered low because very few people

engaged in drinking the raw blood or eating the raw meat. The risk was, however, considered very low among the peri-urban population since home slaughter was rare due to availability of slaughter premises. Following increased migration, the peri-urban population comprised people of different cultures thus the practice of consuming raw meat and blood was also rare among the population.

When comparing the two groups, the risk of exposure to brucellosis was higher among the rural pastoralists group than in the peri-urban group. This was associated with their cultural practices which were more regularly practiced among the rural pastoralists group. In both groups however, handling birth materials without protective gear was the practice associated with the greatest risk of exposure followed by consumption of unpasteurized milk.

CHAPTER FIVE

5 DISCUSSION

Most of the pastoralist areas are very vast with poor infrastructure (Duba *et al.,* 2001). In addition, the pastoralists are highly mobile and this serves as an impediment to their access to education, health care and veterinary services (Montavon *et al.,* 2013).For the zoonotic diseases, man is always at high risk of infection due to some of the perceptions and practices carried out among the population. The knowledge and perception about diseases greatly influence the health seeking behaviour of the patients in a population (Kansiime *et al.,* 2014). This study aimed at evaluating the pastoralists' knowledge and perceptions regarding brucellosis and assessing the risk of exposure to brucellosis among the pastoralists groups in Kajiado County.

In this study, the pastoralists were asked to rank livestock diseases according to their perceived importance. CCPP, LSD and FMD respectively were ranked top in the list. Apparently, these diseases were associated with high morbidity, mortality and low milk yield. In addition, the frequency of their outbreaks was relatively high thus the impact was considered high. These results show some level of consistence with those indicted in a study in Narok (Onono *et al.,* 2013). Surprisingly, brucellosis which is a disease with great zoonotic potential was ranked 7th out of the eleven diseases, with a Z-score of -0.99. Only two groups mentioned it as a livestock disease while most of the participants knew no symptoms associated with the disease in animals. However, the disease was well known in man where Maasai referred to it as "*ugonjwa wa maziwa"* (an illness of milk).

Similarly, anthrax, which is also zoonotic was ranked 5th with a Z-score of -0.63. This shows poor knowledge of zoonotic diseases especially brucellosis among the domestic animals. Such knowledge gap could result when the farmers are not able to relate the disease in man with that in animals as the clinical signs in man vary greatly and differ from those in animals(Corbel, 2006).These results compares with the findings by Moritz *et al.*,(2013), who indicated inconsistence in the knowledge of zoonotic diseases among pastoralists in Northern Cameroon.

The level of agreement on the rank order was very low (0.007) and thus was considered negligible. This inconsistency in the rank order may be due to inadequate knowledge of clinical manifestations of the different diseases and their economic impact. It may also be linked to production systems and the species of animals kept. The rural pastoralists keep large herds of mixed species and thus their rank is influenced by which species dominates and the diseases associated with it. The perceived impact on animal production parameters also influences the rank order of the diseases.

With regard to disease impact on various production parameters, CCPP had the overall greatest impact. High morbidity was associated with CCPP, LSD, FMD and Anthrax while highest mortality was caused by CCPP, FMD and LSD. These results contrasted those by Onono *et al.* (2013) who in their study in Narok County, Kenya, indicated ECF as the top cause of mortality. Milk yield was mainly affected by FMD, ECF, heart water and diarrhoea, and was consistent with the findings by Onono *et al.* (2013). High rates of

abortions were linked to CCPP, FMD, ECF and brucellosis which also agree with the results by Onono *et al.,* (2013) in the pastoral county of Narok.

The rating of the impact of brucellosis on production parameters was fairly low compared to the other diseases. It was associated with negligible mortalities and low effect on milk yield. Though it caused abortions, the rate was lower than that caused by CCPP, FMD and LSD. To the farmer, the impact of loss associated with abortions may not be comparable to loss of animal's life. This is because there is no financial value attached to the unborn foetuses. In addition, milk production is not very key to the pastoralists thus the decline in milk yield may have negligible impact.

The impact of brucellosis on production may therefore not be very critical to the livestock farmer. The short term impact may be perceived as low, but the long term one is colossal. Abortions and infertility associated with brucellosis result in lack of replacement stock thus no continuity. However, the public health implication as well as economic importance of brucellosis in man is enormous. The costs of treatment complicated by diagnosis complexity enhance its importance. Since man acquires brucellosis from animals, control of the disease in man is highly dependent of the control in animals (Díaz Aparicio, 2013).

The knowledge of brucellosis in animals with regard to symptoms, transmission and control was apparently very low compared to that in humans. This finding is consistent with that by Adesokan *et al.* (2013), who indicated poor knowledge of brucellosis among pastoralists community in Nigeria. However, it is contrary to the results by Buhari,

(2015), who indicated higher knowledge of brucellosis in cattle than in man, among the pastoralists in Northern Nigeria. This high level of awareness however, was linked to the pastoralists listening to media teachings on livestock production technologies. In the current study, only in one group did the participants mention abortions as a sign associated with brucellosis in animals. This is consistent with findings by Kansiime *et al.* (2014) who indicated poor knowledge on brucellosis among the pastoralists in Kihurura District in Uganda. Among the Kihurura pastoralists, only a small proportion mentioned abortion as a sign associated with brucellosis in animals.

Regarding transmission of brucellosis to humans, the participants in the current study associated it with consumption of unpasteurized milk and under-cooked meat from infected animals. This is because the patients diagnosed with brucellosis were barred by the doctor from consuming milk and meat. These findings are consistent with those by Kansiime *et al.*(2014) in a study in Uganda, where 97% and 91.4% of the participants suggested consumption of unpasteurized milk and raw or under-cooked meat, respectively as the routes of infection in man.

The current study evaluated various pathways by which man can get exposed to brucella infection. Assisting animals' deliveries without protective gear and consumption of unpasteurized milk were associated with high risk potential among the rural group of pastoralists. This complies with results of a study in Jordan, where less than 6% of the participants believed that livestock owners use protective gear while assisting animal deliveries (Musallam *et al.,* 2015). The risk was higher among the rural pastoralists

compared to the peri-urban pastoralists. This could be due to the cultural practices undertaken by the rural pastoralists. The Maasai community pastoralists keep large herds of mixed animal species and seasonal animal breeding is done. This results in parturition occurring within a specific period of time. n case of brucellosis infection, many people get exposed within a short time as they aid in parturition or handle reproductive tract materials. The aborting animals also contaminate the environment due to close proximity with man, thus the chances of exposure increase (Corbel, 2006).

Regarding disposal of aborted material, six groups said they gave the aborted foetuses to dogs while two groups said that they dispose by burying. This agrees with the results of a study in Jordan where 55% of the participants gave aborted material to dogs while less that 10% disposed by burying or burning (Musallam *et al.,* 2015). *B. abortus* has been demonstrated in dogs (Diaz Aparicio, 2013), thus feeding dogs with aborted foetuses can lead to infection. Such dogs may serve as reservoirs for the disease in both livestock and man due to their close interactions. All these practices increase chances of exposure of brucellosis by skin contact.

Most of the milk used by the rural pastoralists is direct from their animals. They give fresh unpasteurized milk and sometimes colostrum to the children as it is believed to boost immunity. Similar practice was seen among the Fulani pastoralists of Nigeria who consumed milk directly from the animal's udder (Adesokan *et al.*,2013).Sour milk which is a preferred traditional dish in the community is made with unpasteurized milk. *Brucella abortus* has been shown to survive in fermented milk at pH below 4 (Estrada *et*

al., 2005) thus sour milk can predispose man to brucella infection.About 85.7% of human brucellosis cases in Ethiopia were associated with consumption of raw milk (Regassa *et al.*, 2009). It has been shown that about 90% of the milk consumed in sub-Sahara Africa is raw, a practice that poses great health risk to the population (Mfinanga *et al.*, 2003). It is indicated that many zoonotic diseases are passed to man through consumption of unpasteurized dairy products (John *et al.*,2010).

The risk of exposure was, however, low among the peri-urban group of pastoralists. This could be due to the fact that the cultural practices described above are rarely practiced among this group. The farmers keep small herds of livestock compared to those in the rural areas due to small land available as majority are those who have bought land and settled (sedentary). Consumption of raw milk is also low among this group as majority boil their milk before use. This is because majority of the people purchase milk from the outlets or hawkers and are not sure of the source or prior treatment. These results are consistent with those in Jordan where 73% of the participants regularly boiled their milk and consumption of raw milk was negligible (Musallam *et al.*, 2015). Home-made sour milk in the peri-urban is rare due to inadequate supply of milk thus people prefer buying ‘’mala’’, the form of sour milk sold from the shops.

Consumption of raw meat and blood were associated with medium risk in the rural set-up but very low risk in the peri-urban group of pastoralists. In the rural pastoralists, some organs like kidney and liver were consumed raw especially where home slaughter was done. Similarly, raw blood is a common delicacy, regularly consumed during some

traditional ceremonies. Home slaughter is a common practice among the rural pastoralists as the social ceremonies are commonly done and to vastness of the area, there are hardly any slaughter premises in the interior rural areas. The authorized meat inspectors are also very few to adequately cover the entire county. This enhances the practice of home slaughter in these areas hence consumption of raw meat and blood. Consumption of uncooked meat is reported as a common practice among African countries and it has been associated with causing zoonotic diseases in man (Corbel, 2006; John *et al.*, 2010).The wide application of these practices is a clear indication that most people don't know the health risk potential of such practices in transmission of human brucellosis. Adequate knowledge of the disease in both man and animals with regards to symptoms, transmission and control is therefore very essential in the development of control programs.

A possible limitation in this study may have been in the selection of participants as there was no balance in the age groups. However, this was neutralized by the fact that the data collection was by group discussion rather than individual questionnaires. The results were gauged based on the group rather than by individual views. However, using focus group discussions alone may limit knowledge assessment under categories such as age, gender and level of education. It is difficult to rate what percentage of respondents has the knowledge and *vice-versa*. This may be overcome by combining focus group discussions and individual questionnaires where possible. Another limitation is the fact that there was no key informant interview from the same areas. This would have triangulated better the results observed from the pastoralists.

CHAPTER SIX

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From this study, the following conclusions were made:

- The general level of knowledge about zoonotic diseases and especially brucellosis is low among the pastoralist communities. Although human aspect of brucellosis was well known, majority of the people seemed not to know it with respect to animals; thus may not associate it with the disease in man.
- Brucellosis was ranked very low among livestock diseases. The perception of its short term impact on livestock production parameters were also relatively low compared to other diseases. This could make the farmers not consider it as an important disease in animals.
- The perception on risk of exposure to brucellosis in man was higher among the rural pastoralists' than in the peri-urban pastoralist group. This was linked to the cultural practices commonly carried out among the rural pastoralist group. These practices are under-taken in low scale among the peri-urban group of pastoralists.
- In both categories of the pastoralists, handling birth materials without protective gear was the practice associated with the greatest risk of exposure followed by consumption of unpasteurized milk.

6.2 Recommendations

- An immediate action plan on public education regarding brucellosis is crucial. This will enable the people to know the symptoms, transmission and possible control measures of zoonoses.
- Assessment of awareness levels of brucellosis among the human and animal health practitioners especially in the rural pastoralists is crucial. This will go a long way in enhancing public education on zoonoses and the associated risk factors.
- Considering the impact of brucellosis on public health and household economy, there is an urgent need for its control and eradication. Bacteriological and molecular typing to characterize the *Brucella biovars* in the area may be necessary to guide the control and eradication programs.
- Enhanced collaboration between the departments of human medical services and veterinary services in zoonotic disease surveillance and control is very crucial. This approach can also apply in public education and awareness creation among the target population.

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APPENDICES

Appendix 1: Questionnaire

FOCUS GROUP DISCUSSION

1. Which diseases affect cattle, sheep and goats in your herds? (List all mentioned)

No.	Cattle	Sheep	Goats
1			
2			
3			
4			
5			

2. Which of these diseases have the greatest impact when they occur in the herd?

   List the effects of each disease that make it important- (pair wise ranking).

	1	2	3	4	5	Score	Rank
1							
2							
3							
4							
5							

3. How do these diseases impact on the following parameters? (Disease scoring-use stones)

Disease	Milk yield	Abortions	Mortality	Morbidity	Others
1					
2					
3					
4					
5					

4 Have you heard of brucellosis in humans and animals?

b) What are the main symptoms in animals?

5 a) How is brucellosis spread to man?

6 What do you normally do when the diseases occurs in your herds?

7 What is the estimated cost of treatment for the disease in man? Ksh…….

Appendix 2: Focus group discussion

LIST OF PARTICIPANTS

Group……Location……...…….Date……

Choose the category that fit you for age and education.

Age in years: [a] 25-30 [b] 31-40 [c] Above 40

Education: [a] Primary [b] Secondary [c] Tertiary

Occupation: [a] civil servant [b] Full time on-farm [c] Self employment

No.	Name	Gender	Age	Education	Occupation

Appendix 3: FOCUS GROUP DISCUSSION

ATTENDANCE LIST

Group……Location…….Date……

No.	Name	Signature

Appendix 4: Kendall's coefficient of concordance showing the level of agreement across groups

Kendall's coefficient of concordance	
Group factor:	**Disease**
Coefficient (W):	0.007
Adjusted for ties:	0.014
Sample size:	8
Number of samples:	11
Sum of squares:	36.00
Chi-square:	1.11
Degrees of freedom:	7
Probability:	0.993

Degrees of freedom = 10

Chi-square probability < 0.001

H = 46.56 (adjusted for ties) with 10 degree of freedom

Probability >46.56 = 0.0

Appendix 5 : Risk assessment for exposure to brucellosis in the pastoralist's production system of Kajiado County 2015

Risk analysis steps	**Description of evidence for risk profile**	**Estimates of epidemiological data**	**Systems affected**	**Authors**
Hazard identification	Sero-Prevalence of Brucella in animals and man.	17% in man (n=174), 13% in goats (n=400), 11% in cattle (n= 200)	Pastoralists system in North Turkana	Nanyende, 2007 (MSC Thesis)
	-Sero-prevalence of brucellosis in animals and man	Overall sero-prevalence for the three counties (Kajiado, Kiambu and Marsabit) were: 16% in humans 8% in animals; human and livestock sero-prevalence was 3	Extensive (Pastoralists) production system (Kajiado and Marsabit) and intensive production system (Kiambu)	Ogola *et al.*, (2014).

		and 4 times higher in Marsabit than in Kajiado, which was 6 and 3times higher than Kiambu respectively		
	Prevalence of Brucella in cattle milk;	Overall prevalence of 4.9% by indirect ELISA and 3.9% by milk ring test (MRT) at consumer level and 2.4% - ELISA and 3.4% - MRT at informal market.	Milk from Extensive production system (Narok and Nakuru) and intensive production system (Nairobi and Kiambu	Kang'ethe *et al.*, (2007)
Hazard characterisation	-Types of Brucella organisms isolated in Kenya:	Milk sampled from urban consumers in Nairobi and Nakuru showed prevalence of 4.7% (n=10) by	Milk from Extensive production system (Narok and Nakuru)	Kang'ethe *et al.*, (2007)

	Brucella abortus in cattle milk -*Brucella melitensis* biovar 1and *Brucella abortus* biovar 3 isolated in cattle	MRT and 5.1% (n=11) by ELISA; and from Rural consumers: 3.2% (n=7) by MRT and 4.6% (n=10) by ELISA. *Brucella melitensis* biovar one isolated from cattle milk from Central Kenya, and Brucella abortus biovar 3 from aborted foetal materials from cattle in Central and Eastern provinces of Kenya	and intensive production system (Nairobi and Kiambu Central province is characterized by intensive production system while Eastern is mainly characterised by semi-extensive production system	Muendo *et al.*, (2012)

Exposure assessment	Risk factors for exposure assessed were: Consumption of unpasteurized milk -Consumption of raw meat -Consumption of raw blood -Handling infected aborted materials or assisting animals during parturition without protective gloves		Peri-urban pastoralism system and rural pastoralism system	Own survey
Risk characterization and estimation	Risk of human infection with Brucella organisms is		Peri-urban pastoralism system and rural	Own survey

	higher in the rural pastoralism than in the peri-urban pastoralism system		pastoralism system	