A SURVEY OF ANIMAL-BITE INJURIES IN HUMANS AND THE ECONOMIC BURDEN OF RABIES IN MACHAKOS COUNTY, KENYA

A thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Veterinary Epidemiology and Economics

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DECLARATION

This thesis is my original work and has not been presented for the award of a degree in any other University

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DEDICATION

To my parents, Mr. & Mrs. Konah Andrews Sr: Thank you for the moral, spiritual and financial foundation you've laid for my academic success today. You sowed a mustard seed that has geminated into fruits and so shall you reap the fruits of your labor. To my sons, Paul and Uhuru: Your patience of being away without mom's love is the greatest gift you could give me, thank you. You are the best deal I ever negotiated. My siblings, Elvis, Konah Jr, and Nuemene: May you be inspired by this thesis and relentlessly work to pursue higher education for a better future. To my husband Senesee Geso Freeman: Thank you for all the emotional and moral support, and the enthusiasm. You were always there. Last but not the least, this thesis is inspired by, and dedicated to, rabies victims. May there be no more.

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ABBREVIATIONS AND ACRONYMS

ABLV……………………………… Australian Bat Virus

ARS…………………………………Anti Rabies Serum

CNS…………………………………Central Nervous System

EBLV …………………………… European Bat Lyssavirus 1

ERIG……………………………… Equine Rabies Immunoglobulin (ERIG)

HRIG……………………………… Human Rabies Immunoglobulin

Id………………………………… Intra dermal

Im………………………………… Intra muscular

KDO……………………………… Kangundo

LBV……………………………… Lagos Bat Virus

LWT……………………………… Local Wound Treatment

ANOVA…………………………… Analysis of Variance

MOKV…………………………..... Mokala Virus

PET………………………………… Post Exposure Treatment

RABV……………………………… Rabies Virus

RAT……………………………… Rapid Antigen Tests

GBD……………………………… Global Burden Disease

DALYs…………………………… Disability Adjusted Life Years

YLLs……………………………… Years Life Lost

IMG…………………………………Immunoglubolins

ABSTRACT

This thesis describes a survey of a retrospective and prospective study conducted in Machakos County and the epidemiology of animal-bites in humans in Machakos, Kenya. The objectives of the study were: 1) to characterize animal-bite injuries in humans in Machakos County; 2) to estimate the burden of rabies in Machakos County; and 3) to test the application of ‘One Health’ Approach in the control of rabies in the County.

Cases of animal-bites in humans that were reported at the two main district hospitals in the county, namely, Machakos (Level 5) and Kangundo (Level 4) were reviewed. Retrospective data on animal-bites were collected from records kept at the Machakos and Kangundo district veterinary offices and the corresponding district hospitals (2009-2012). Detailed data on animal-bites were collected prospectively for three months (May-July, 2013) at the district veterinary offices and the two hospitals. During 2009-2012, a total of 2636 cases of human bites by animals were reported at the hospitals. Dog bites accounted for the majority (95%; 2505/2636) of the cases. During the same period, only a quarter (25%; 748/2636) of bites cases was reported to the veterinary offices (95%; 710/748 by dogs). From (May –July, 2013), 121 cases were reported at the two hospitals and none at the veterinary offices. Approximately a half (49.5%; 60/121) of the bites was caused by unknown unvaccinated dogs against rabies and 50.5% by dogs of unknown vaccinated status. Some cases came from distant villages in the county including Masinga, Matuu and Ikombe. Data on cases of animal-bites in humans reported to the two hospitals and district veterinary offices were also collected to assess the flow of information between the two ministries responsible for rabies control activities. A huge proportion (88%; 106/121) of the bites victims were not given anti-rabies vaccine sourced from the hospitals and had to purchase it from private pharmacies at a price of Ksh 900 per dose. Thirty eight percent (46/121) of the bite cases received only a three-dose vaccination regimen of 1ml of vaccine on days (0, 3, 7), while 27% received a 5-dose regimen of 1ml of vaccine on days (0, 3, 7, 14, 28).

Data were entered and cleaned in MS Excel®. Summary statistics including graphs (bars and pie charts), frequency tables and means were generated using the spreadsheets. Data were then exported to Genstat (15^{th} Edition SP1 Version) for statistical analysis. Chi square statistics was used to determine association between categorical variables in the dataset and the type of animal bite. ANOVA statistics were used to determine mean differences across groups. A p value of < 5% was considered significant. A GIS Programme called GIS Map Info Professional was used to plot graphs showing locations and bites incidences within Machakos County.

In conclusion, this study revealed that the incidence of animal-bites in humans, and therefore the risk of rabies, is high in Machakos County and that the domestic dog is the most important species. Control of rabies is often seen as the responsibility of veterinary authorities, but demonstration of the public health importance of rabies and the benefits of disease control to the public health authorities will encourage involvement of the health sector in control efforts. In Machakos, the integration of hospitals, medical and veterinary sectors is likely to be crucial for effective disease control, as shown by the success of recent rabies control strategies. Rabies control targeted at vaccinating the domestic dog should stepped up and closer collaboration between the medical and veterinary personnel should be enhanced in line with the 'One Health' approach if the control of this ancient and most dreadful of human infections is to be successful.

Key words: Animal-bites; Rabies; Machakos; "One Health; Control.

CHAPTER ONE

1.1 ANIMAL BITES

Animal bites particularly those by dogs are a growing problem in large urban centers with large and poorly supervised dog populations (Knobel *et al*., 2005). The closeness of man to domestic dogs exposes him to not only bites but also other infections with serious consequences. Injuries inflicted on humans can cause permanent scars, severe disability or even death (Lembo *et al*., 2010). These can in addition result in infections that can incapacitate or kill the victim. Some of the important diseases that can be transmitted to humans via bites by animals include rabies, pasteurellosis, cat scratch fever, tularemia and tetanus (WHO, 2005). Besides the public health implications of animal bites, other consequences may include medical costs to the individual or family, governmental administrative costs in control aspects involving the health and police departments, the distress to bitten person and their families, and possible legal action taken against the specific owner of the biting animal (WHO, 2005). Most of the animal bites are preventable. At the community level, principle control strategies include reducing the number of domestic dogs roaming in the community (animal control) and teaching people how to refrain from behaviors likely to provoke the bites.

Of all the human diseases associated with animal bites, rabies ranks the most important in large areas of the developing world. Rabies has been considered as the most important human disease associated with animal bites. Indeed, it is estimated that at least one person dies from rabies every ten minutes globally (WHO, 2012). This tragic statistic still holds true today. Each year, rabies claims around 70,000 human victims, mainly children in developing countries (WHO, 2012). Over 95% of human rabies cases are due to bites by infected dogs and, unlike many other diseases, we have all the necessary tools to eradicate it. In Asia, Africa and Latin America, the domestic dog is the principal reservoir and transmitter of the disease to humans. Almost 99.9% of the 70,000 human deaths due to rabies reported annually worldwide occur in Asia (56%) and in Africa (44%) and 89% of these are associated with dog bites (WHO/DFID, 2006). Every year, more than 15 million people worldwide receive post-exposure vaccination to prevent the disease- this is estimated to prevent hundreds of thousands of rabies deaths annually (WHO, 2012). However, these statistics are conservative estimates as most cases of the disease go unreported mainly due to weak surveillance mechanisms of rabies in most of the developing world. In a previous study of rabies in Machakos District, Kenya. Kitala *et al*. (2000) showed that the disease was grossly under-reported by as much as 72 times.

The costs due to rabies may be categorized as: direct human costs from post-exposure treatment; indirect costs for the control of rabies in dogs; livestock losses; and surveillance costs (Knobel *et al*., 2005). Direct medical costs include those related to acquisition of the biological items (rabies vaccines and immunoglobulins) and administration (costs related to materials and staff salaries). The indirect patient costs include out-of-pocket expenses for patients, such as transport costs to and from rabies-treatment centers, and loss of income while receiving treatment.

The estimation of animal-bites in humans is a useful indicator of the risk of infection in humans and can be used to project the burden of the disease in the community (Fevre *et al*., 2005). However, very few studies have been conducted in Kenya to collect this vital information that can be useful in policy formulation on rabies control in the country. This is particularly important in Machakos County, where rabies has remained endemic since it was first confirmed in the country in the 1950's (Kitala *et al*., 2000). Indeed, rabies remained endemic in the county even when it was well controlled in the rest of Kenya in the 1960's and 1970's through mass dog vaccination campaigns and restriction of dog movements (Kariuki and Ngulo, 1985). The endemic status of rabies in Machakos can be attributed to the large, poorly supervised and inadequately vaccinated dog population in the county (Kitala *et al*., 2000). The incidence of annual animal-bite in Machakos has been estimated at 234 cases/100,000 inhabitants, with up to 97% of the bites attributable to dogs (Kitala *et al*., 2001).

There is limited literature on the occurrence of rabies in Machakos. Kitala *et al*. (2001) conducted a study on comparison of vaccination strategies for the control of dog rabies in Machakos District, Kenya. It is likely that the dog population size and density, and rabies incidence has changed. This current study aimed to collect information on animal bites in humans in Machakos County and to project the burden of rabies. The information would assist in the formulation of sound policies, guidelines and strategies for the control of rabies control in the County.

1.2 Objectives

1.2.1 Overall Objective

The overall objective of the study was to characterize animal-bite injuries in humans and estimate the burden of rabies in Machakos County, Kenya.

1.2.2 Specific objectives

The specific objectives of the study were:

1. To characterize animal-bite injuries in humans in Machakos County;

2. To estimate the burden of rabies in Machakos County;

3. To assess the application of 'One Health' Approach in the control of rabies in Machakos County.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Animal bites

Animal bites are serious public health concerns though under reported in the developing countries (Gautret and Parola, 2012). Besides bite injuries and the subsequent adverse psychological impact, dog bites can be complicated by subsequent infections including rabies. Of all the potential infections rabies is thought to have the highest case fatality rate (Rupprecht *et al*., 2007). Study by Gautret and Parola (2012) reported cases of animal bite injuries caused by dogs in urban areas of France especially in Marseille and reported that the culprit dogs belong to street beggars. Their recommendation was that programmes offering low cost rabies vaccination and veterinary care to pets belonging to street beggars needed to be considered. Such programmes could be implemented in other major cities of France and Europe where street beggars were frequently seen.

In Southern Bhutan, the media has frequently reported increasing stray dog populations, rabies outbreaks and risk of dogs biting humans (Tenzin *et al*., 2011). A total of 324 dog bite victims were interviewed in a study in Bhutan and other surrounding hospitals and reported that the annual incidence of dog bites differed between the hospital surroundings (Tenzin *et al*., 2011). In the study, most of those bitten were males (62%); mostly children aged 5-9 years. No direct fatal injuries were reported. The incidence of death from rabies was 3.14% (CI 1.57-6.29) per 100,000 populations. Based on these findings, Tenzin *et al* (2011) noted the need for increased awareness about the risk of dog bites and rabies, particularly to children living in rabies- endemic areas of Bhutan. United States of America recorded 279 deaths in humans related to dog bites between

1979 and 1994. This led to a review of existing local and state dangerous dog laws including proposals for adoption of the dogs (Sacks *et al*., 1996).

A survey in Switzerland reported 325 per 100,000 populations bite and search incidence in the year 1998 (Overall and Love, 2001). Dogs contributed 60% and cats 25% of the cases. Most cases were reported in persons below 20 years old. Children below ten years of age were more affected (Overall and Love, 2001).

Fevre *et al*. (2005) carried a survey on dog bite injuries in Uganda and used the findings to estimate mortality due to rabies at the national level. Children were mostly bitten and death occurred because up to 41% of patients did not complete required course of Post Exposure Treatment. Thus, they recommended the need for active animal bite surveillance studies to improve mortality estimates and determine the true burden of rabies in Uganda.

Fitzpatrick *et al*. (2012) carried a survey about rabies control through dog vaccination in Wildlife and the annual canine vaccination campaigns achieving 67% coverage in Ngorongoro and 42% coverage in Serengeti should be sufficient to control rabies outbreaks with 95% confidence. These coverage levels are lower than the WHO recommended annual target of 70% (WHO, 2005). Focus on annual coverage targets, since rabies vaccination in Tanzania is conducted through annual campaigns and since the WHO target is specified as such. The estimates of required coverage were much lower than previous recommendations of 70% coverage on a consistent basis (Coleman and Dye, 1996). The study suggested that lower coverage levels may be effective than those predicted to be necessary for annual campaigns in Kenya (Kitala *et al.*, 2002). This was probably related to a high R0 value (2.44) found in the Kenyan study.

According to Kenya Rabies Country Report, 2013, in Kenya rabies is endemic and has existed with varying incidence levels since 1912 when the first case of rabies was diagnosed in a dog. The first human case was from a woman in western Kenya around Lake Victoria basin in 1928. Like in most of the developing world, the domestic dog is the major reservoir and transmitter of rabies to both human and livestock in Kenya. Although rabies is wide spread in most of the Counties, the true burden of the disease in unknown. On acknowledging the gaps that exists between human and animal sectors (Livestock and wildlife), the Ministry of Public Health and Sanitation and the Ministry of Livestock Development established a One Health office (Zoonotic Disease Unit) that is nested between the two Ministries in order to establish and maintain an active collaboration and thus working towards diminishing the threat of zoonoses, including rabies.

2.2 Epidemiology of Rabies

2.2.1 Aetiology

Rabies (*Rabidus*, Latin for mad) is a highly fatal nervous disease of man and all other warm-blooded vertebrates. The rabies virus is a member of the Rhabdoviridae family of rod or bullet-shaped viruses (*Rhabdos*, Greek for rod). The Rhabdoviridae family is divided into two genera, *Vesiculovirus* (vesicular stomatitis and related viruses) and *Lyssavirus* (*Lyssa*, Greek for rage or fury). The latter group includes rabies and the rabies-related viruses (Balsamo and Ratard, 2010).

Until 1956, the first isolation of rabies-related viruses in Africa was believed to be unique and antigenically distinct from the other members of Rhabdoviridae family 8 (Nel and Rupprecht, 2007). This warranted the creation of the genus Lyssavirus for viruses responsible for rabies-like encephalitis. The genus was first divided into four serotypes (1-4). Serotype 1, rabies virus (RABV); Serotype 2, lagos bat virus (LBV); Serotype 3, Mokola virus (MOKV); Serotype 4, Duvenhage virus (DUVV). Further isolations of new bat lassavirus in Europe, then Australia and the progress in genetic characteristics of several genes of (N, P and G) supported the delineation of seven genotypes (1-7) confirming and expanding the antigenic data. These included genotype 5, European bat Lyssavirus 1 (EBLV-1); genotype 6, European bat Lyssavirus 2 (EBLV-2); genotype 7, Australian bat Lyssavirus (ABLV). Each genotype sub lineage corresponds to variants circulating in specific geographic regions and/or animal hosts. The genotypes further segregate in two Phylogroups including genotypes 1, 4, 5, 6 and 7 (Phylogroup I) and 2 and 3 (Phylogroup II) (Pinheiro de Souza *et al*., 2010)

2.2.2 Occurrence and distribution

Rabies is a classic example of a multi-host pathogen for which the identification of reservoirs has proven challenging (Nel, 1993; Cleaveland and Dye, 1995; Bingham *et al*., 1999; Johnson *et al*., 2003; Bernardi *et al*., 2005). In Africa and Asia, domestic dog rabies predominates among reported and confirmed cases and domestic dogs are the reported source of infection for over 90% of human cases (WHO,1999); however, it has been argued that this may reflect surveillance bias and that the role of wildlife is poorly understood (Swanepoel *et al*., 1993; Wandeler *et al*., 1994). Rabies has a worldwide distribution, with only certain countries mainly islands and peninsulas, being historically free of the disease or having succeeded in eradicating it (Blancou, 1988; WHO, 1989; WHO, 1991). The disease does not occur in Australia and Antartica

(Wandeler *et al.*, 1994). In Western Europe, rabies was recognized as early as 1271 when it was prevalent among wolves. An outbreak of the disease in dogs was first confirmed in the Eastern Cape Province of South Africa in 1893 by inoculation of rabbits. In the developed world, rabies in dogs has been controlled, but the disease has established itself in the wildlife (Finnegan *et al*., 2002). In North America, various species of wildlife are involved including the fox, raccoon dogs and skunks, while in much of Europe; the fox is the principal reservoir (Finnegan *et al*., 2002). In spite of rabies been confirmed in a variety of wildlife species in Africa, the domestic dog still remains the most dangerous reservoir of the disease because of its close association with man (Taylor *et al*., 2001). In Kenya, rabies has been confirmed in a variety of wildlife species including the jackal, honey badger, civet rat, mongoose, hyena, ground squirrel, and in livestock (cattle, sheep, goats, donkeys) (Chong, 1993).

2.2.3 Excretion of rabies virus

The excretion of rabies virus and the levels of virus excreted are the most important factors for transmission. Rabies virus can be excreted in saliva of infected animals for many days after the onset of clinical signs of disease. Rabies virus has also been found in dog saliva up to seven days before signs of rabies were observed (Fekadu *et al*.,1982). The "carrier state", a chronic infection with or without a period of clinical signs during which animals can transmit disease by excreting virus in saliva, can be found in dogs. Rabies virus has been isolated from the saliva of clinically normal dogs and dogs with transient paralysis (Charlton, 1988). Fekadu *et al* (1982) found that saliva collected on day 42 and 169 from a dog that had recovered from experimental Ethiopian strain rabies inoculation produced fatal rabies in mice inoculated intracerebrally. Fekaduet *et al*

(1982) also reported that viable virus could be isolated from the palatine tonsil of an experimentally infected dog up to 305 days after its recovery. Rabies virus can be excreted from the saliva of cats for one to three days and cattle for one to two days prior to onset of signs. The virus may be detectable earlier in wildlife than in dogs, in skunk up to four days prior to clinical disease onset, one to two days in foxes and 12 days in insectivorous bats. Virus can be excreted in urine and this may lead to transmission by aerosol in foxes and bats. Excretion in milk also occurs but is considered to not represent a major hazard because viral particles will be destroyed by enzymes present in the milk (Kaplan et al., 1986; Beran and Steele, 1994)

It has also been shown that the virus can be excreted in urine and this may lead to aerosol transmission in foxes and bats **(**Finnegan *et al*., 2002**)**.

2.2.4 Routes of transmission

The commonest mode of transmission in man is by the bite of a rabid animal or the contamination of scratch wounds by virus- infected saliva. However, other routes have been implicated in the past, such as through mucous membranes of the mouth, conjunctiva, anus and genitalia. Infection by aerosol transmission had been demonstrated in experimental animals and has been implicated in human infection in rabies-infected bat caverns and in several laboratory accidents. Transmission of rabies virus usually begins when infected saliva of a host is passed to an uninfected animal. The most common mode of rabies virus transmission is through the bite and virus-containing saliva of an infected host. Though transmission has been rarely documented via other routes such as contamination of mucous membranes (i.e., eyes, nose, mouth), aerosol transmission, and corneal and organ transplantations.

Exposure to infectious saliva from a rabid animal by direct bite is the most common route of infection. Rabies virus cannot penetrate through normal skin but licking, scratching or contact with freshly abraded skin or mucous membranes such as conjunctiva, nasal mucosa and the anus may allow transmission of infection (Panichabhongse, 2001). Other documented routes of transmission include:

- Ingestion: Transmission via oral exposure is essentially limited to the most highly susceptible species. This can occur in wildlife among predators and prey (Renwick, 2007).
- Airborne: Inhalation of rabies aerosol into the nose and throat may be an important route of transmission in some species of animals living in high density populations such as foxes and bats but is extremely rare in humans (Panichabhongse, 2001). Two accidental cases of airborne infection in humans by inhaling aerosol rabies virus in the laboratory were reported (Panichabhongse, 2001). Aerosolized virus from bat urine has been suspected as an exposure pathway for wildlife investigators.
- Transplantation: Corneal transplantation has been reported to result in transmission from human to human (Gastaud, 1989).
- Milk borne transmission: This has been demonstrated in sheep and neonatal transmission through milk of lactating dams of wild reservoir species may be more frequent (Panichabhongse, 2001).
- Environmental transmission: Transmission of rabies virus by fomites has occurred

occasionally and the role of predation can be important for spillover hosts since during predation, a wound may occur due either as a defensive bite or as an oral laceration from a bone fragment. Such wounds can potentially allow transmission of rabies virus from prey to the predator (Panichabhongse, 2001).

2.5 Pathogenesis

All species of mammals are susceptible to rabies virus infection, but only a few species are important as reservoirs for the disease. In the United States, distinct strains of rabies virus have been identified in raccoons, skunks, foxes, and coyotes. Several species of insectivorous bats are also reservoirs for strains of the rabies virus.

Rabies virus entry occurs through wounds or direct contact with mucosal surfaces (Xinjian *et al.*, 2011). The virus then either replicates in non-nervous tissues or directly enters peripheral nerves and travels by retrograde axoplasmic flow to the central nervous system (CNS). Both motor and sensory fibres may be involved depending on the animal species. The incubation period varies from 2 weeks to 6 years (average 2-3 months) depending on the amount of virus in the inoculums and site of inoculation (Xinjian *et al*., 2011). The proximity of the site of the virus entry to the CNS increases the likelihood of a short incubation period (Xinjian *et al*., 2011).The virus then moves from the CNS via retrograde axoplasmic flow within the peripheral nerves, leading to infection of some of the adjacent non-nervous tissues: for example, secretory tissues salivary glands. The virus is widely dissimilated through the body at the time of clinical onset. The first clinical symptom is usually neuropathic pain at wound site. This is caused by virus replication in dorsal root ganglia causing ganglionitis. Two major presentations are observed:

furious and paralytic forms that cannot be correlated with specific anatomical localization of rabies virus in CNS (12) (Wandeler and Bingham, 2000). Peripheral nerve dysfunction is responsible for weakness in paralytic rabies. In furious rabies, electrophysiological studies indicate anterior horn cell dysfunction even in absence of clinical weakness (Hemachudha *et al*., 2005).Without intensive care; death occurs within few days (1-5 days) after the development of neurological signs. Rabies is inevitably fatal.

2.6 Post Exposure Treatment (PET)

Rabies has a 100% case fatality rate; meaning that once clinical signs are manifest treatment will be futile and death will inevitably occur. Thus, it is very important that treatment be initiated immediately a person has been exposed to a suspect rabid animal. The World Health Consultation on Rabies (2004) in its last meeting drew up guidelines on the management of patients exposed to rabies suspect animals. Post-exposure treatment (PET) consists of local treatment of the wound, initiated as soon as possible after an exposure, followed by the administration of passive immunization, if indicated, and a potent and effective rabies vaccine that meets WHO criteria. The PET may be discontinued if the animal involved is a dog or cat that remains healthy for an observation period of 10 days after the exposure occurred; or if the animal is humanely killed and proven to be negative for rabies by a reliable diagnostic laboratory using a prescribed test. If the animal inflicting the wound is not apprehended, PET should be instituted immediately. The World Health Organization (WHO, 2012) and Centers for Disease Control (CDC, 2012) have guidelines for post exposure treatment and assessment of each category of exposure and level of risk. Two kinds of rabies immunoglobulins, human rabies immunoglobulin (HRIG) and equine rabies immunoglobulin (ERIG), are currently effective forms of passive immunization used in serious or high risk exposure cases except for the exposed person who has been vaccinated previously. The HRIG is given at 20 IU/kg and ERIG at 40 IU/kg by infiltrating one half around the wound and one half intramuscularly followed by five doses of cell culture vaccine one each on day 0, 3 7, 14 and 28 (Dreesen *et al*., 1996).

2.7.1 Local treatment of wounds

Elimination of rabies virus at the site of the infection by chemical or physical means is an effective mechanism of protection. Recommended first aid measures include immediate and thorough flushing and washing of the wound for a minimum of 15 minutes with soap and water, detergent, povidone iodine or other substances of proven lethal effect on rabies virus. If soap or an antiviral agent is not available, the wound should be thoroughly and extensively washed with water. Other treatments, such as the administration of antibiotics and tetanus prophylaxis, should be applied as appropriate for other bite wounds.

2.7.2 Administration of rabies biological products for passive immunization

The role of passive rabies immunization products is to provide the immediate availability of neutralizing antibodies at the site of the exposure before it is physiologically possible for the patient to begin producing his or her own antibodies after vaccination. There are three classes of rabies biological products for passive immunization available at present: human rabies immunoglobulin (HRIG); equine rabies immunoglobulin (ERIG) and highly purifies (F (ab') 2 products produced from ERIG. The dose for HRIG is 20 IU/kg body weight, and for ERIG and F (ab') 2 products is 40 IU/kg body weight. (Greene and Dreesen, 1990)

2.7.3 Vaccine administration for active immunization

Intramuscular regimens

Cell-culture or purified embryonated egg rabies vaccines having a potency of 2.5 IU per single intramuscular (im) immunizing dose should be applied according to one of the following regimens. Five-dose intramuscular regimen (Essen regimen): One dose of vaccine is administered intramuscular on days 0, 3, 7, 14, and 28. Injections must be given on the upper arm (deltoid region) or in small children, into the anterolateral thigh muscle. Vaccine should never be administered into the gluteal region, where absorption is unpredictable. Abbreviated multisite intramuscular regimen ("2-1-1" or Zagreb regimen): One dose of vaccine is administered into the left and one into the right upper arm (deltoid region) on day 0 followed by one dose into the upper arm (deltoid region) on days 7 and 21. This schedule saves two clinic visits and one vaccine dose.

Intradermal regimens

A limited number of rabies vaccines have been recognized to date by the WHO as safe and efficacious for PET when administered by the intradermal (id) route in two different regimens. Updated Thai Red Cross intradermal regimen ("2-2-2-0-2"): The schedule involves the intradermal administration of one dose of vaccine, in a volume of 0.1 ml at two different lymphatic drainage sites, usually the left and right upper arm, on days 0, 3, 7 and 28. This regimen considerably lowers the cost of vaccination as the total volume of vaccine required is much less than that needed for im regimens. Eight-site intradermal (id) regimen ("8-0-4-0-1-1" regimen): One dose of 0.1 ml administered intradermal at eight different sites (upper arms, lateral thighs, suprascapular region, and lower quadrant of abdomen) on day 0. On day 7, four 0.1 ml injections are administered id into each upper arm (deltoid region) and each lateral thigh. Following these injections, one additional 0.1 ml dose is administered on days 28 and 90. Intradermal injections must be administered by staff trained in this technique. Vaccine vials should be stored between 2^0C and 8^0C after reconstitution and the total content should be used as soon as possible, but at least within 8 hours. However, intradermal injection needs to be done by well trained staff. The regimen may be slightly different in each country. Effective PET can reduce both mortality rate and psychological sickness.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. Study area

The study was conducted in Machakos County (Figure 3.1). The county has a human population of 1,098,584 people (2009 census). Machakos County is characterized by a hilly terrain with altitudes ranging from 1000 to 1600 metres above sea level. It has a land mass covering 669.70 Km^2. Most of the County is semi-arid but has also some high potential areas where a mixed crop-livestock production system is practiced. It borders Nairobi and Kiambu counties to the West, Kitui and Mwingi counties to the East, Makueni County to the South, and Embu County to the North (Figure 3.2). Machakos stretches from latitudes 0º 45’ south to 1º 31’ south and longitudes 36° 45’east to 37° 45’ east. The hierarchical administrative structure of the county, from the smallest, includes sub-districts, divisions, locations and sub locations. Machakos County has eight constituencies: Machakos Town, Masinga, Matungulu, Mavoko, Mwala, Kangundo, Kathiani and Yatta (www.machakosgovernment.com).

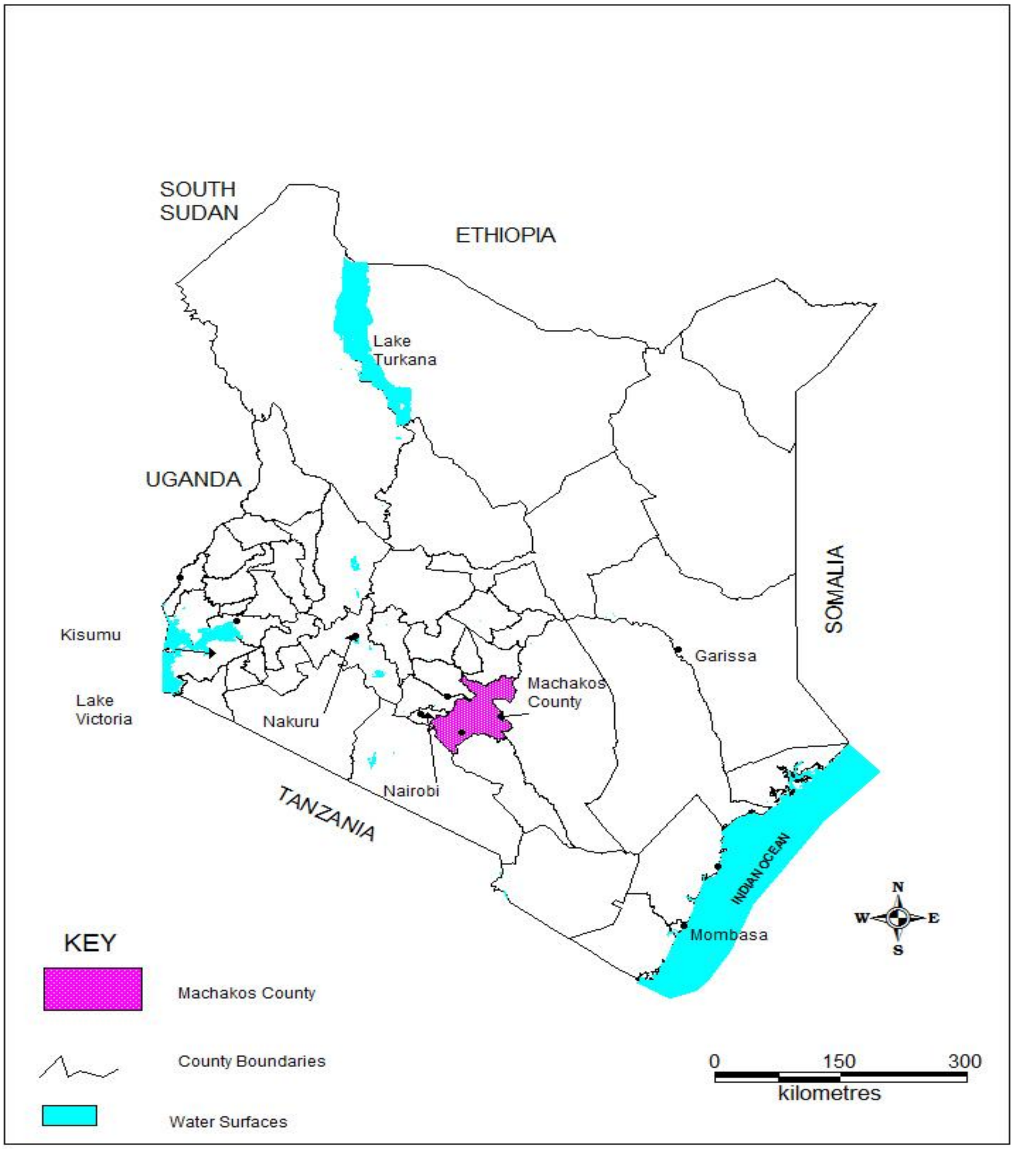

Figure 3.1: Map of Kenya showing the location of Machakos County (GIS Map Info Professional).

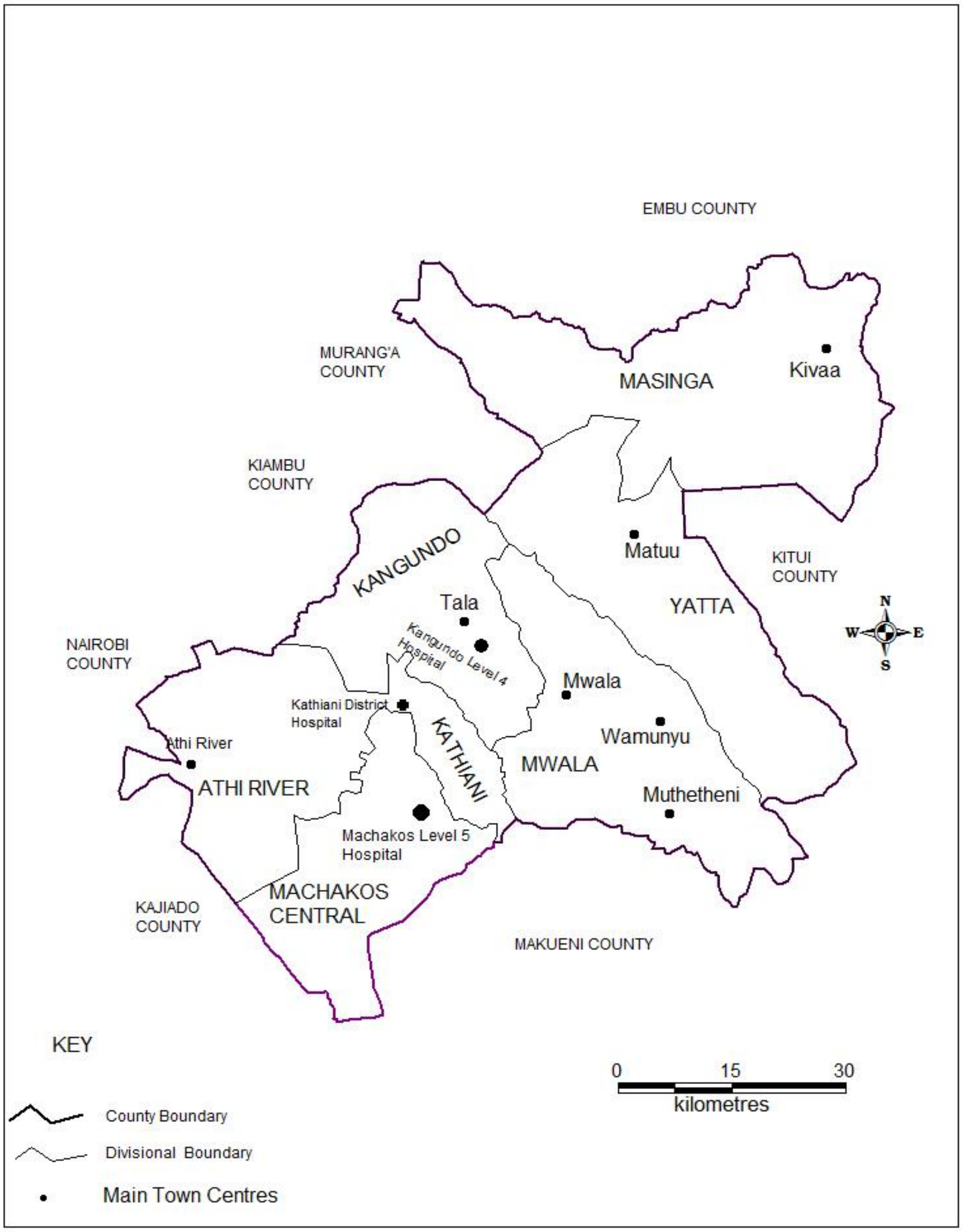

Figure 3.2: Map of Machakos County showing administrative units and major urban centers, and the location of MKS (Level 5) and KDO (Level 4) Hospitals. (GIS Map Info Professional).

3.2. Study design

The study was a survey of animal-bites of humans reported to the two main district hospitals in the county, namely, Machakos (Level 5) and Kangundo (Level 4) (Figure 3.2). The study was conducted in two parts. In the first part, retrospective data on animal-bites reported at the two hospitals for a period of 4 years (2009-2012) were collected while in the second part detailed data on animal-bite injuries of humans reported to the same hospitals were collected for three months (from May to July, 2013). During the three-month period, data on cases of animal-bites of humans reported to the Machakos and Kangundo District Veterinary offices were also collected as a check on the flow of information between the two ministries responsible for rabies control in Machakos.

3.3 Data collection

Data were collected from the two district hospitals, the Machakos Level 5 General Hospital and the Kangundo Level 4 District Hospital, and from the two corresponding district Veterinary Offices within the County.

3.3.1 Hospital data

Previous data on reported cases of animal-bites in humans were extracted from the records kept at the two hospitals. Although data for a ten-year period were sought, it was only available for the previous four years before the study begun (2009-2012). Information sought from the records included date when the bite occurred, geographical location, site on the body the bite occurred, sex and age of bitten person, post exposure treatment (PET) given and any other relevant information.

In the three-months (May-July, 2013) prospective phase, detailed data on bite incidence were collected including date of bite, age and sex of bitten person, PET administration, distance travelled to the hospital (in kilometers), and cost incurred (fare and cost of vaccines) (Appendix 1). The investigator personally filled the forms and when not present, a records clerk at the hospital filled them. The clerk was previously briefed on the objectives and methodology of the study.

3.3.2 Data from the Veterinary office

The records kept at the two district veterinary offices were used to extract data on reported cases of animal-bites in humans for four-years (2009-2012). The data collected included occurrence of the bites, location of biting animal, sites of bite, species of biting animal and their owner if known, diagnostic results when the heads of killed biting animal were available for laboratory submission, and cost of rabies control (dog vaccinations and submission of specimens for diagnosis). The three-month (May- July, 2013) prospective data collected included additional information as shown in Appendix 2. When the investigator was not available, an animal health assistant at the veterinary office filled the data collection forms; after they were previously briefed on the objectives and methodology of the study.

3.4 Data handling and analysis

Data were entered and cleaned in MS Excel®. Summary statistics including graphs (bars and pie charts), frequency tables and means were generated using the spread sheets. Data were then exported to Genstat (15th Edition SP1 Version) for statistical analysis. Age was categorized into 5 groups (<15 years, 15-30 years, >30- 45 years, >45- 60 years and >60 years). Chi square statistics was used to determine association between categorical variables in the dataset (age group, gender, hospital etc) and the type of animal bite (coded as 1 for dog bite and 0 for other bites). ANOVA statistics was used to determine mean differences across groups (e.g. dose groups 1 to 5). A p value of $< 5\%$ was considered significant. A GIS Programme called GIS Map Info Professional was used to plot graphs showing locations and bites incidences within Machakos County.

CHAPTER FOUR

4.0. RESULTS

4.1. Retrospective data on cases on animal bites

4.1.1. Species of biting animals

During the four-year period (2009-2012), a total of 2636 cases of human bites by animals were reported at both Machakos and Kangundo hospitals converting to an average of 659 bites per year. Dog bites accounted for 95% (2505/2636) of the total bites. Only a small percentage of the bites (3%; 80/2636) were from cats (Table 4.1). Other animal species causing bites during the period included camels, cows, donkeys, goats and unspecified wildlife species. Bites from wildlife accounted for only 1.3% of the total bites (Figure 4.1).

Table 4.1: Retrospective data of animal- bites of humans reported at the MKS and KDO Hospitals in Machakos County, 2009-2012.

Year bite reported	Animal Species							
	Dog	Cat	Donkey	Wild animal	Cow	Camel	Goat	Total
2009	310	8	6	3	3	1	1	332
2010	816	28	4	2	2	1	0	853
2011	753	24	6	4	1	0	0	788
2012	626	20	7	7	2	0	1	663
Total	**2505**	**80**	**23**	**16**	**8**	**2**	**2**	**2636**

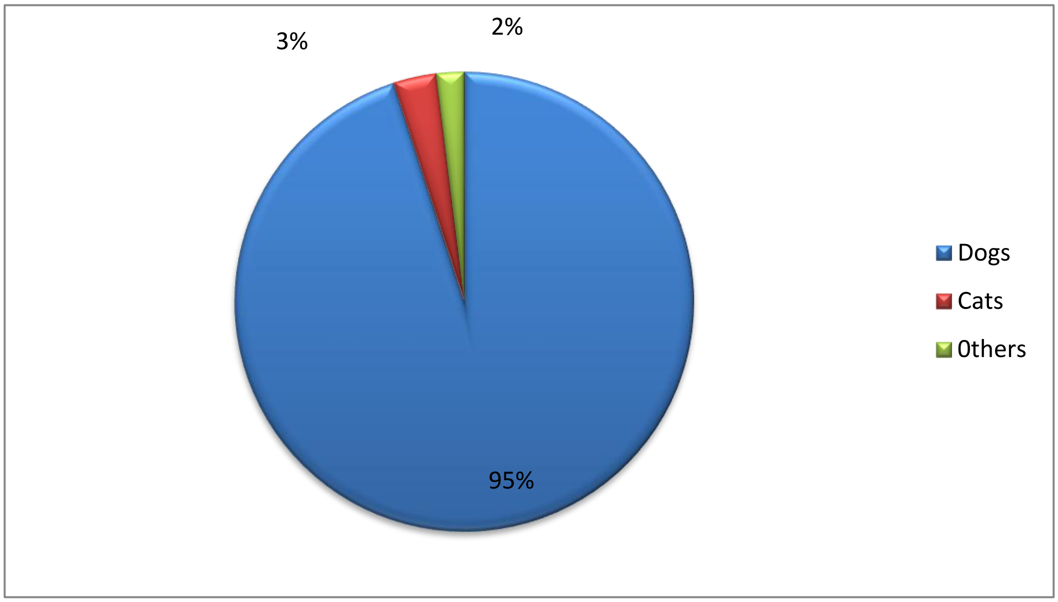

Figure 4.1: Proportions (%) of species of biting animals reported to the MKS and KDO hospitals, Machakos County, 2009-2012.

4.1.2. Spatial distributions of reported bite incidents

Cases of animal-bites injuries were distributed widely across Machakos County. The distribution of the bite incidents at the two district hospitals was widespread throughout the county. Most of the cases reported were concentrated within and around the two hospitals of Machakos and Kangundo. However, some cases came from distant villages in the county including Masinga, Matuu and Ikombe (Figure 4.2). In Figure 4.2, where there were no red dots of location of biting incidences, it was confirmed that there was another district hospital- Kathiani (Level 4) District Hospital where animal-bites victims sought PET.

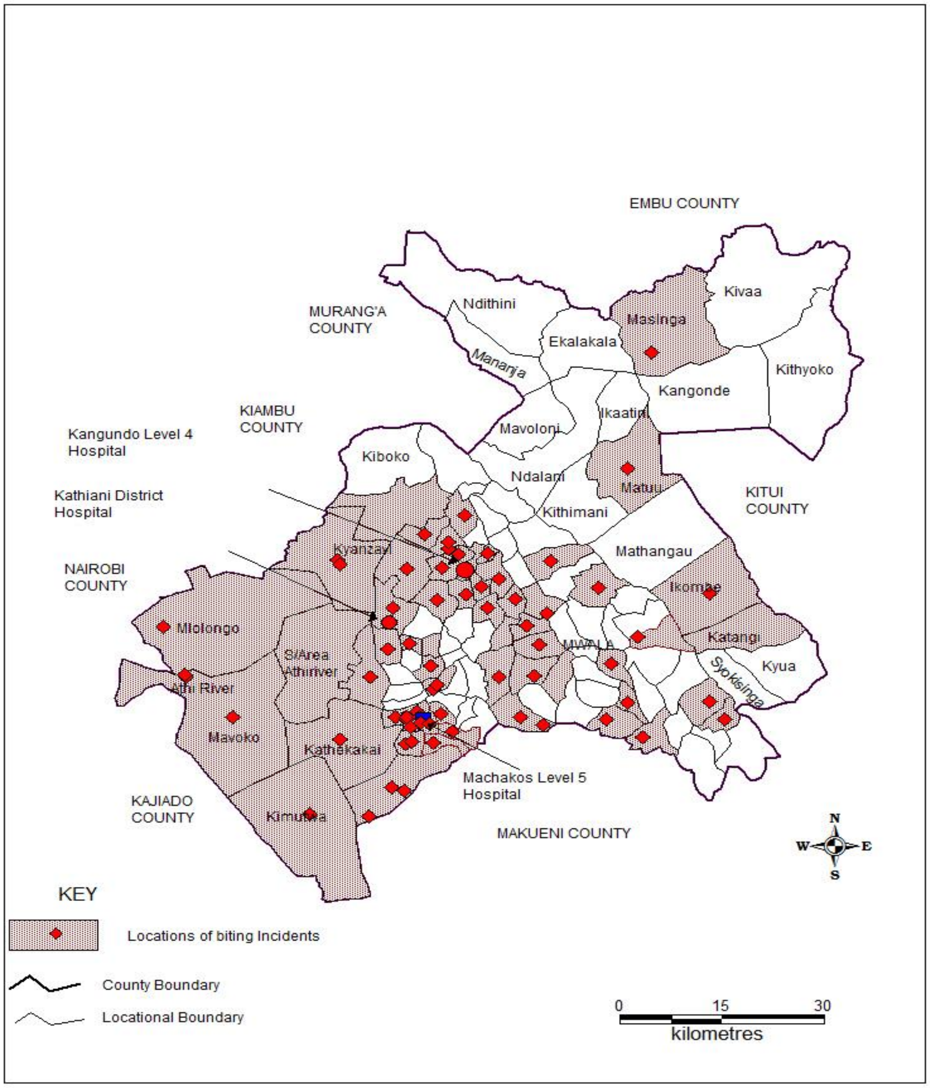

Figure 4.2: Spatial distribution of cases of bites of humans by animals reported to MKS and KDO hospitals, 2009-2012. (GIS Map Info Professional).

4.1.3. Temporal distribution of bite incidents

The number of reported bites for period 2009-2012 increased from a low of 225 cases in the month of Jamuary and peaked in the month of June with 290 cases (Figure 4.3). Another peak in the number of cases reported occured in the month of September and thereafter declined steadily to a low of 190 cases in December (Figure 4.3).

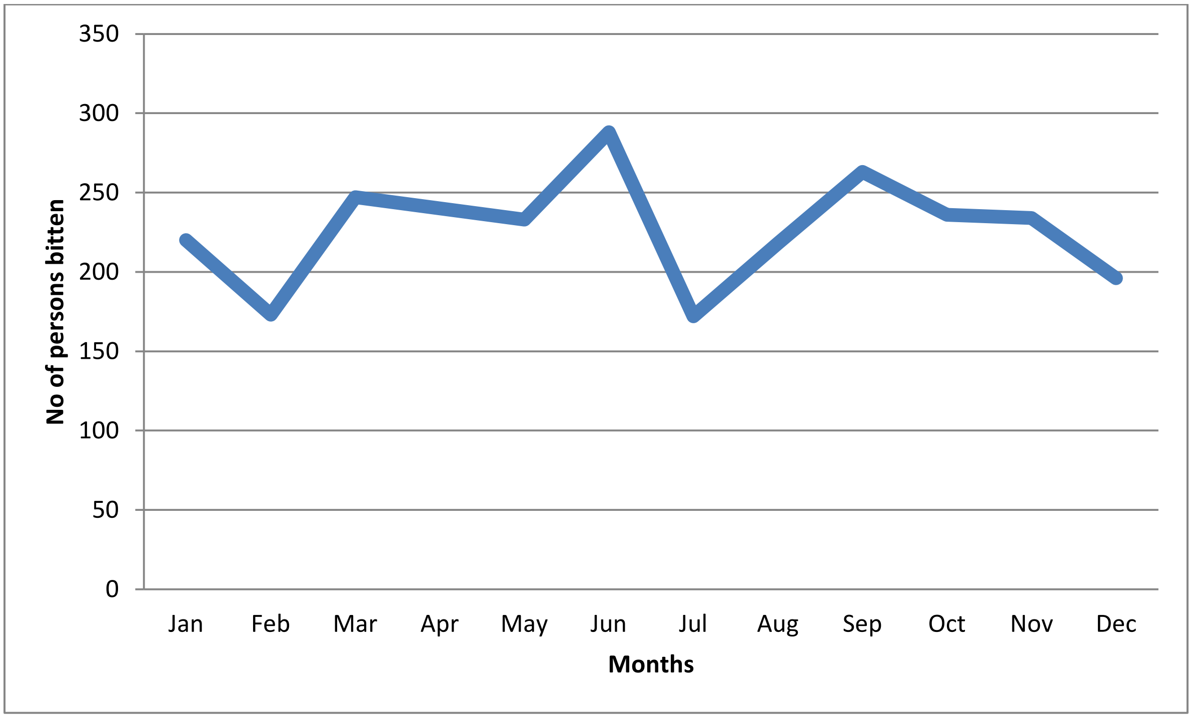

Figure 4.3: Distribution of cases of animal-bites of humans by month of the year reported to the MKS and KDO Hospitals, 2009-2012.

4.2 Review of previous Veterinary data on animal-bites

A total of 748 cases of bites were reported to the Machakos and Kangundo District Veterinary offices in the period 2009-2012. This was a quarter (25%; 748/2636) of animal bites cases reported to the two hospitals in the same period. This indicates that most of the people bitten by animals reported directly to the hospitals, ignoring the veterinary offices. However, the pattern of biting animals reported mirrored that of the hospitals; 94.9% (710/748) of the bites were due to dogs, 2.7% (20/748) cats, and 2.4% (18/748) due to other species including cows, donkeys and unspecified wildlife species (Table 4.2).

Table 4.2: Cases of animal-bites of humans reported to the MKS and KDO district veterinary offices, 2009-2012.

	Animal Species					
Year	**Dog**	**Cat**	**Cow**	**Donkey**	**Wild animal**	**Total**
2009	116	5	3	2	1	127
2010	186	5	2	1	1	195
2011	226	5	1	1	1	234
2012	182	5	3	1	1	192
Total	**710**	**20**	**9**	**5**	**4**	**748**

The distribution of the locations where bites occurred was similar to that reported at the hospitals though it was far lesser than cases reported at the two district hospitals (2636 cases). The reasons was due to the fact that animal-bite victims did not see it necessary to report at the District Veterinary Offices (DVO), so they went straight to the hospitals to seek PET. The DVO was seen as a place where disputes were settled between the owner of bitting dog and the person bitten as to compensate the victim with transport cost to and fro rabies treatment centers or purchase of the vaccine. Most of the reported bites occurred in places close to the veterinary offices although a few were from far away areas as shown in Figure 4.4.

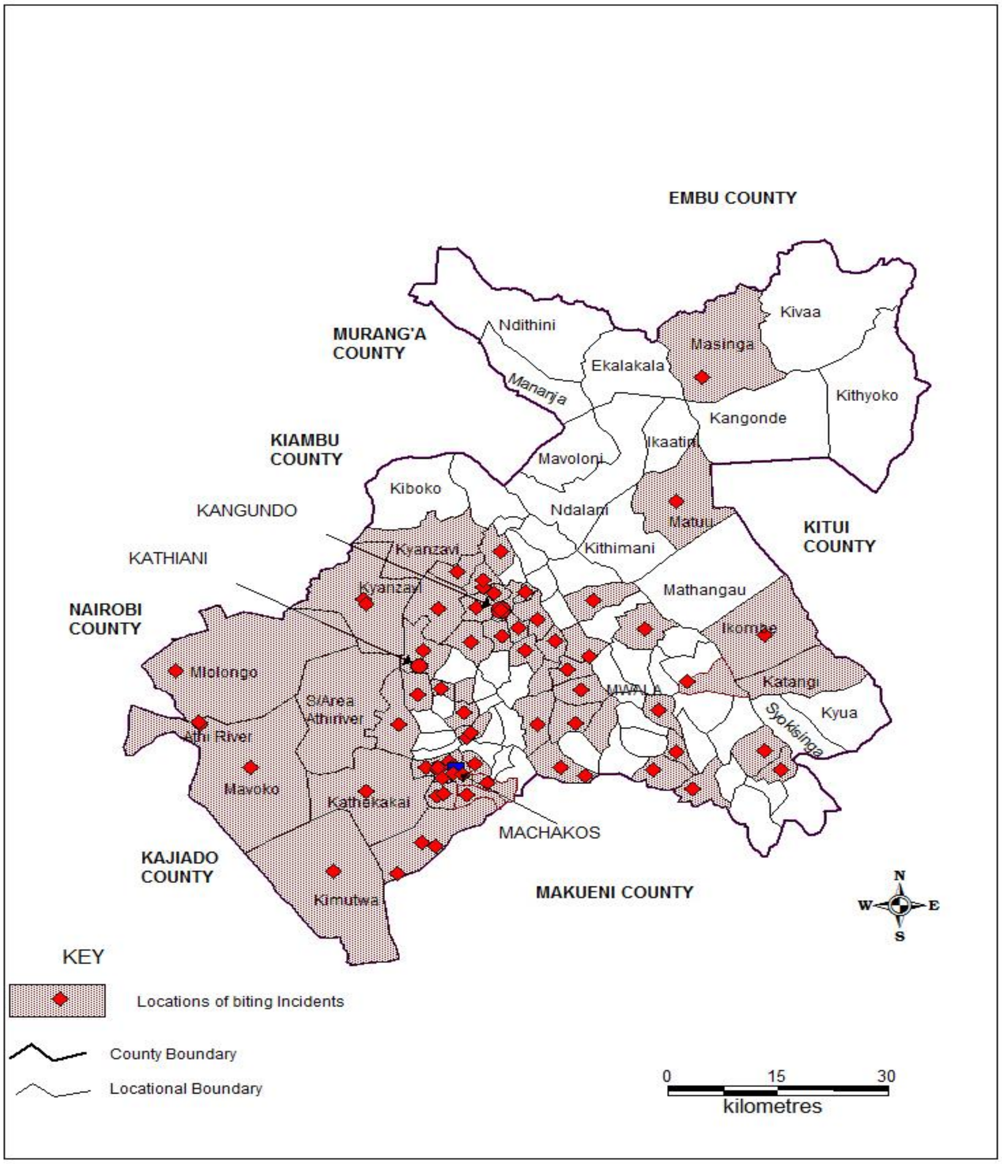

Figure 4.4: Spatial distribution of cases of bites of humans by animals reported to the district veterinary offices in MKS and KDO, 2009-2012 (GIS Map Info Professional).

The temporal pattern of bite cases was similar to that reported at the hospitals with peak cases reported in the month of April (91 cases) and thereafter there was a steady decline to a low of 30 cases reported in the month of December (Figure 4.5).

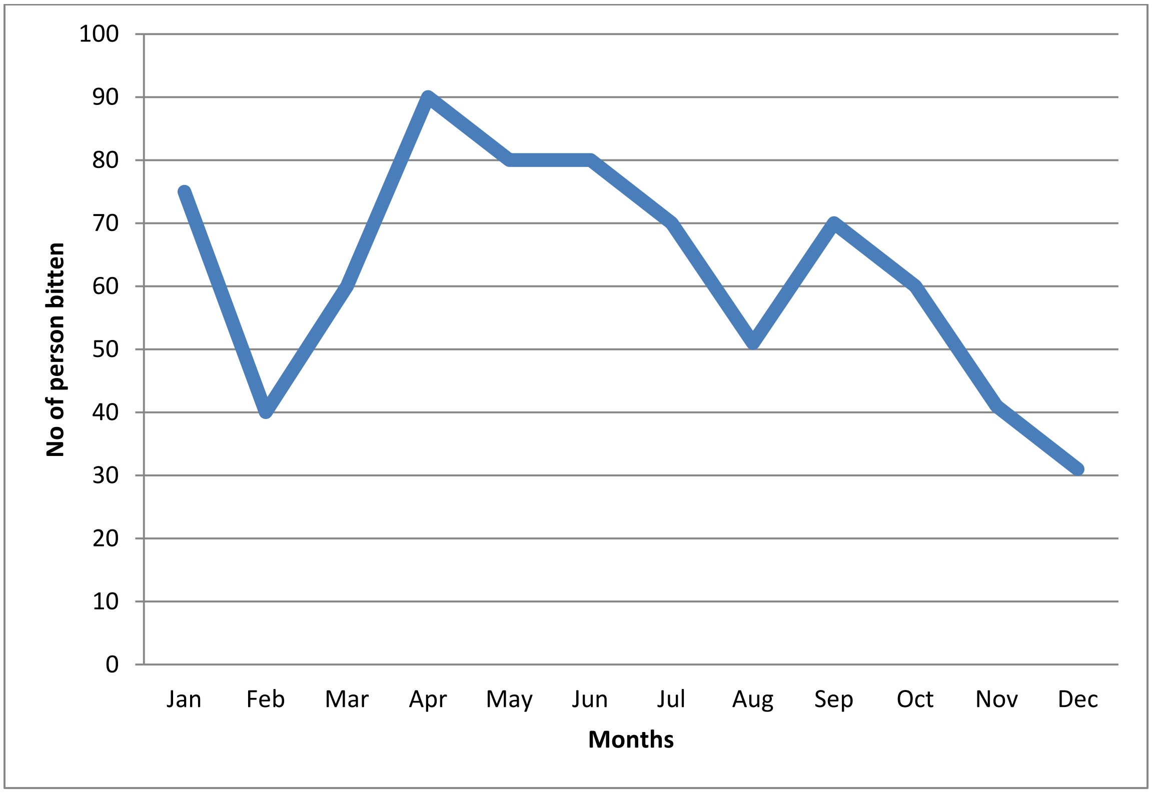

Figure 4.5: Temporal distribution of cases of animal-bites of humans by month of the year reported to the MKS and KDO Veterinary Office, 2009-2012.

4.3.1: Species of biting animals

During the three months (May-July, 2013), a total of 121 cases of animal-bites were reported at the Machakos (81 cases) and Kangundo (40 cases). The vast majority (95%; 109/121) of the bites were inflicted by dogs. Cats, accounted for 4% (5/121) of the bites. Other species that reportedly caused bites are shown in Table 4.3. No statistical association ($p>0.05$) was reported between animal species and other categorical variables included in the study.

Table 4.3: Species of animals causing bites reported to the MKS and KDO Hospitals, May-July, 2013.

	Animal Species				
Month	**Dog**	**Cat**	**Donkey**	**Wild Animal**	**Total**
May	22	2	1	1	27
June	26	1	1	0	28
July	61	2	3	1	67
Total	**109**	**5**	**5**	**2**	**121**

4.3.2 Age and sex distribution of human animal-bite cases

The age and sex distribution of the 121 cases of animal-bites is shown in Figure 4.6. The majority (59%; 72/121) of the bites occurred in children less than 15 years of age. 30% were in boys. Despite the fact boys have the tendency of provoking dogs; boys were mainly the owners of the dog. This was shown in the vaccination campaign conducted in Kangundo in 2013, where boys were responsible for taking the dogs for vaccination as compared to older people. Also, there's seemed to be a relationship between dogs and boys. There was no significant association between dog bites and age and sex distribution ($P>0.05$).

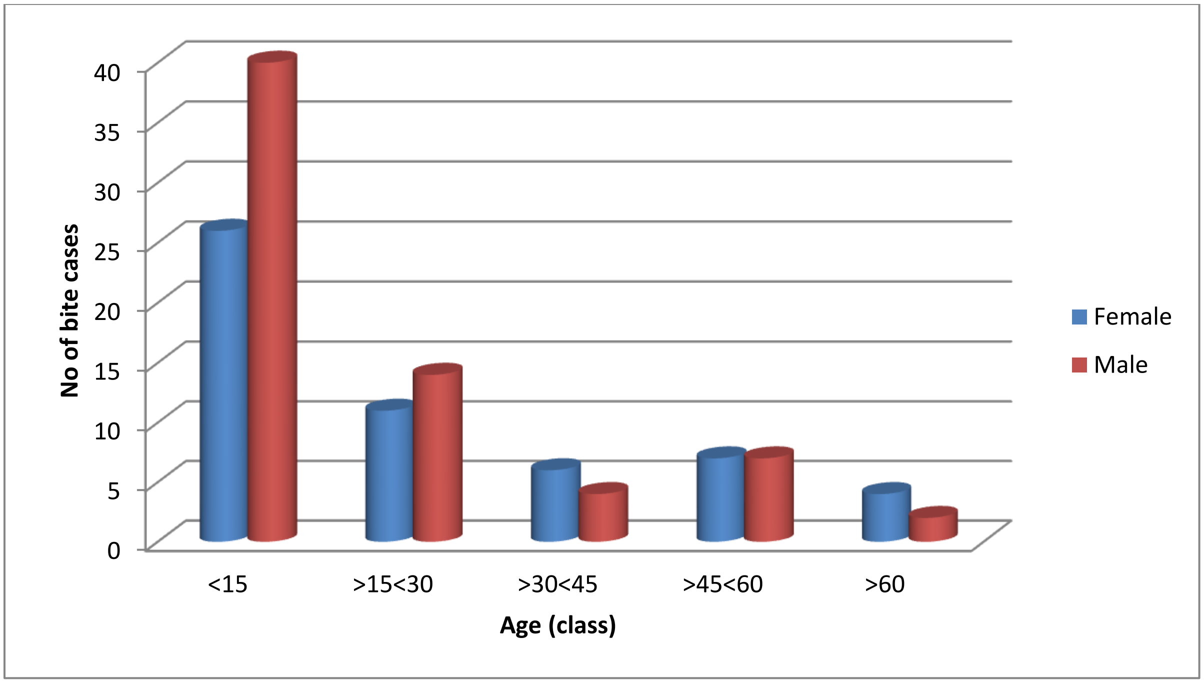

Figure 4.6: Sex and age distribution of animal-bites by dogs in MKS and KDO hospitals, 2009-2012.

4.3.3 Type and site of exposure

Types of exposure on the body included Puncture wounds, lacerations, scratches and saliva. Most (63%; 76/121) of the exposures were puncture wounds. Other exposures included scratches (18%), lacerations (17%) and contact with saliva (2%) of the rabies suspect animal (Figure 4.7).

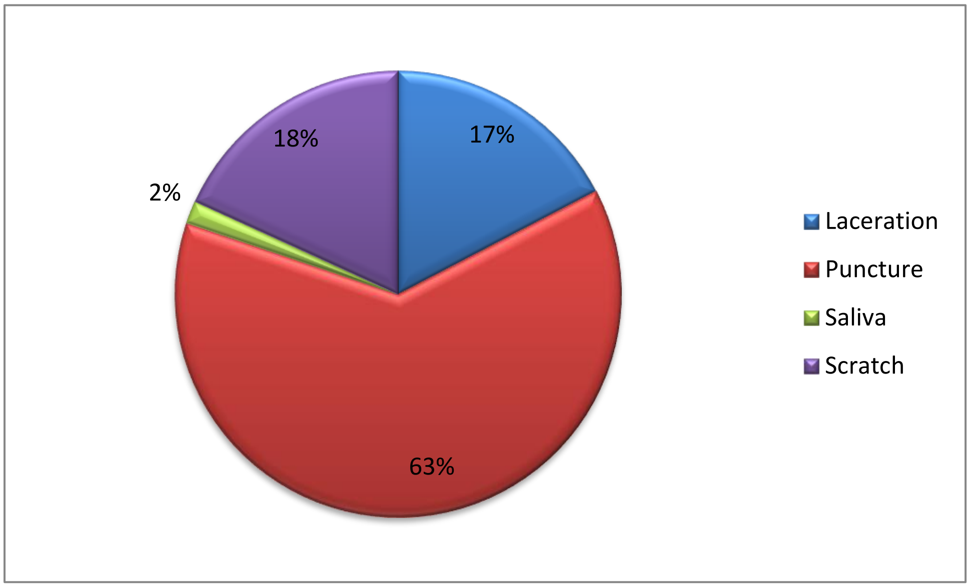

Figure 4.7: Types of exposures in 121 human cases of animal-bites reported at the MKS and KDO hospitals, May-July, 2013.

The distribution of exposure is shown in Figure 4.8. Most (51%; 62/121) of bites were inflicted on lower extremities (legs, buttucks), 24% (29/121) on the upper extremities (head, hands)

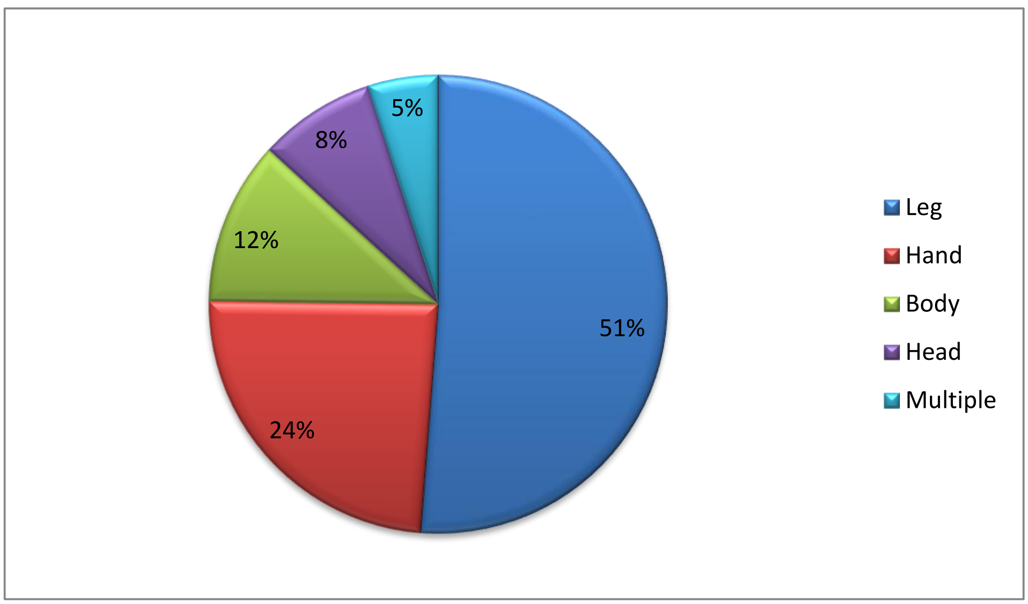

Figure 4.8: Sites of exposure on the body of 121 cases of human-animal bites.

4.3.4 Ownership of biting animal and their vaccination status

Of the 109 persons bitten by dogs, 40.5%; (49/121) said they knew the owner of the biting dogs while a huge propotion 59.5%; (72/121), did not know the owner. Only 12 (9.9%) of the bite-cases reportedly were bitten by dogs that were claimed vaccinated against rabies. Approximately a half (49.5%; 50/121) of the bites were caused by known unvaccinated dogs against rabies and (50.5%; 71/121) were bitten by dogs whose vaccination status was unknown.

4.3.5 Clinical signs exhibited by biting animals

Only 57 (47%) of the 121 bite cases described the clinical signs shown by the dogs that bit them. The most prominent signs reported were aggression (43%), hyperaemic eyes (25%), paralysis (18%), and excessive salivation (14%). Twenty-two (18%) of the bite victims said they knew the other people who were bitten by same dog that bit them.

4.3.7 Transport cost while receiving PET

The average transport cost for patients making a single trip to treatment centres was 1907±1339 (Table 4.4).

Table 4.4: Table showing number of doses and transport cost (KSH) incurred while receiving treatment at the MKS and KDO Hospitals, May-July, 2013.

Number of dose received	**number**	**Mean±SD**	**Median**
1	27	1907±1339	1500
2	10	1515±1342	1000
3	46	1211±1228	1000
4	4	625±499	500
5	33	1609±1556	100

4.3.7 Post-exposure treatment practices

Almost three quarters (73%) of the 121 bite cases reportedly applied some local wound treatment after the bite which comprised washing the wound with plenty of water and soap. This was done before seeking medical help at the hospital. A huge propotion (88%; 106/121) of the bite cases did not receive the antirabies vaccines from the public hospitals and had to purchase it from the local private pharmacies at a price of Ksh 900 per dose. The vast majority (38%; 46/121) of the bite cases received a three-dose vaccination regimen of 1ml of vaccine on day 0,3,7. As shown in Fig. 4.9, only 27%; (33/121) of the cases received the recommended vaccination regimen of 1ml on days 0,3,7,14, and 28. Based on reports from the Medical Officers of Health (MOH) at the two hospitals, the whole county receives on average about 100 doses of antirabies vaccines annually from the Division of Vaccines and Immunization of the Ministry of Health. This explains why most of the bite cases were referred to purchase the vaccines from the local pharmacies and may also explain why only a few managed to receive the reccommended 5-dose vaccination regimen presumably because of the high cost of the vaccines; a full 5-dose regimen would cost Ksh 4,500. This would be in addition to the cost of bus fare to the hospital and other out-of-pocket expenses.

A person exposed or attacked from wildlife or bats should receive post exposure treatment. The animal involved in the attack should be killed, and tested as soon as possible, regardless of whether it is considered to be a suspect rabies case. A person exposed or attacked by any non wild animal (privately owned, unvaccinated pet or stray dog for example) should have PET initiated immediately. The animal should be confined and observed for at least 10 days. This may require caging if repeat observation will be difficult. If the animal shows no evidence of rabies during the seven to ten day period of observation or is proved rabies negative, human PET is then discontinued. If a person is attacked by an animal of unknown status and the animal then disappears, a full course of PET should be applied.

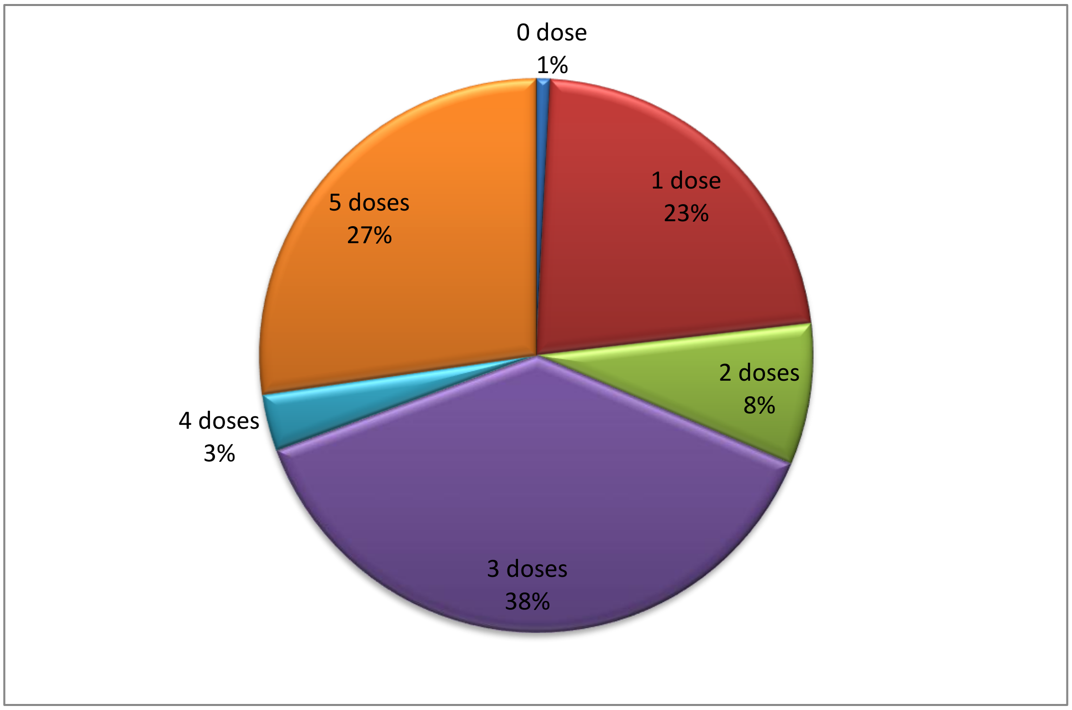

Figure 4.9: Distribution of doses (%) of anti rabies vaccines administered to 121 human cases of animal-bites at the MKS and KDO hospitals, May-July, 2013.

4.4 Cases of animal bites reported at the district veterinary offices

During the 3 months (May-July, 2013), only 27% (33/121) cases of animal-bites were reported at the veterinary offices in Kangundo and Machakos. During the discussion with the veterinary officials, it became apparent that only a few cases of bites are reported to their offices mostly by people bitten by dogs whose owner they knew and they wanted the treatment expenses to be covered by the dog owners.

4.5 Burden of a disease as determined conventionally by WHO

The term “burden of disease” can refer to the overall impact of diseases and injuries of public health problems as measured by the financial cost, mortality, morbidity or indicators at the individual level, at the societal level, or to the economic costs of diseases. The GBD is often quantified in terms of Quality- Adjusted Life Years (QALYs) or Disability-Adjusted Life Year (DALYs) both of which quantify the number of years lost due to a disease YLDs).

DALYs is a health gap measure, which combines information on the impact of premature death, and of disability and other non-fatal health outcome. It is used to help measure the burden of disease and the effectiveness of health interventions. It is an indicator showing loss from premature mortality, based on early death judged against the average life expectancy in the population of a developed country. Thus the burden of disease is a measurement of the gap between current health status and an ideal situation where everyone lives into old age, free of disease and disability.

Besides the public health implications of animal bites, burden of a disease can be both direct and indirect: the costs included disease control in dogs, surveillance cost, livestock losses, acquisition of biological items (vaccine cost and IMG), administrative cost (materials and staff salaries), out of pocket expenses for rabies patients (medical costs to the individual or family), income incurred while receiving treatment to and fro rabies centers, and the psychological fear of the disease., governmental administrative costs in control aspects involving the health and police departments, the distress to bitten person and their families, and possible legal action taken against the specific owner of the biting animal (WHO, 2005)

4.6 "One Health" approach

One Health is a worldwide strategy for advancing animal health care and their ecosystems through communication and collaborations. It aims to improve health and well-being through the prevention of risks and the mitigation of the effects of crises that originates at interface between humans, animals and their environment. The sole purpose of the "One Health" is to promote multi (cross) sectoral and collaborative approach; and to promote a "whole society" approach to health hazards as a systemic change of perspective in management of zoonoses (WHO, 2005).

In the control of rabies in Machakos County, the "One Health" will entail more concerted effort between the Ministry of Health, Ministry of Livestock, District Veterinary Hospitals and Veterinary offices, the Zoonosis Disease Unit, and other institutions involved for an efficient and effective system to ensure communication and collaboration if the control of this dreadful of human diseases is to be contained.

Animal-bites cases reported to the veterinary department (25%) indicated that animal-bites victims did not regard the DVO, instead reported cases straight to the hospitals. Indeed, those who reported to the veterinary authorities did so because they knew the owners of the attacking dogs and wanted to be compensated for the cost incurred during the period of seeking PET.

CHAPTER FIVE

5.1 DISCUSSION

In this study, data were collected from two hospitals, the Machakos Level 5 General Hospital and the Kangundo Level 4 District Hospital, and from the two corresponding district Veterinary Offices within the County. The study revealed that rabies was a major public health problem as it is in other parts of the developing world. The domestic dog was the main species causing bites with other species playing a minor role. Infection with the rabies virus usually follows a bite by a rabid animal, mostly dogs and other carnivores as the virus is present in the saliva of such animals (Swanapoel, 1993). It was unfortunate that data on human rabies deaths were not obtained at the two major hospitals due to poor recording system. In addition, the medical staffs were not certain of what led to the death of patients presenting with nervous signs as most rabies deaths were not confirmed via laboratory tests, a phenomenon common in the developing world (WHO, 2005). However, laboratory confirmed rabies cases in animals particularly in dogs were regarded at the two veterinary offices. Thus, it is likely that most patients that died after exhibiting nervous signs had indeed died of rabies at the two hospitals. This has been observed in Malawi where 59% of patients dying after showing nervous signs had actually died of rabies (Jonasson, 2014).

The results of the current study are in accordance with what was reported in the county previously that dogs were the main reservoir species of rabies virus (81% of confirmed rabid animals) and were also the principal transmitter of the virus to man (92% of bite cases), (Kitala *et al*., 2000). The distribution of bites cases was widely spread throughout the county including some cases from far flung areas. However, majority of the bites were reported from areas around the two hospitals. This was an indication that the distance to the hospital was key to deciding where post exposure treatment (PET) was sought. This can be explained by the fact that seeking PET was expensive and included costs such as bus fare, cost of vaccines and other miscellaneous expensive especially for children who had to be escorted by adults. During the period under review, there was a severe shortage of anti-rabies vaccine as only 100 doses were procured annually for the entire county (MoH, personal communication), hence the reason why most (88%) patients had to seek the anti-rabies vaccines at market rates (Ksh 900 equivalent to US$10) for a single dose and Ksh4,500 (US$50) for the 5-dose regimen. Indeed, some 1380 of the bites cases took only 3-doses of the vaccines. An important outcome of this study is the fact that the cost of PET was out of reach to most of the rural poor residents of the county, the majority (60%) of whom live on less than a dollar a day (World Bank, 1990). There were some areas in the center of the county with very few reported bite cases; this might be explained by the presence of another Level 4 hospital at Kathiani sub-county. It is probably that most bite cases sought PET from neighboring counties of Kitui, Kiambu, Muranga and Embu, including Nairobi County.

Consistent with other studies (Kitala *et al.*, 2000) boys especially those below 15 years of age suffered more (780 cases) than girls (513 cases). This can be explained by the fact that boys rather than girls have a tendency of provoking dogs hence the high probability of being bitten. Due to their short stature, boys are more likely to suffer bites on their heads with a high chance of getting rabies after a short incubation period (Beran and Steele, 1994). Like in most other similar studies (Kitala *et al.*, 2000) a small portion (4%) of the animal bites cases knew the owner of the biting animal. One can only imagine the fear and anxiety of the bites cases and family members as they practically sought PET.

The residents of Machakos County appeared to know more of the aggressive form of rabies (44%) relative to the paralytic forms (18%). This is in conformity with the work of Kitala et al., (2000) who documented a high frequency (44%) of occurrence of the aggressive form of rabies and little (18%) of the paralytic form. Most rabid dogs tend to wander at random and cover huge distances exposing many people and livestock; this may explain why most of the biting dogs were unknown in the areas where the attacks took place. Indeed 18% of the bite cases reportedly knew of other people bitten by the same dog that attacked them.

In regards to the One Health approach in the county, there appeared to be minimal collaboration between the medical and veterinary professions charged with the control of rabies in Kenya. Only 25% of the animal-bites cases were reported to the veterinary department indicating that they overlooked them and reported straight to the hospitals. Indeed, those who reported to the veterinary authorities did so because they knew the owners of the attacking dogs and wanted to be compensated for the cost incurred during the period of seeking PET. There is a need for more concerted effort between the two ministries and other institutions involved if the control of this dreadful of human diseases is to be contained, and the need for an efficient and effective system to ensure the smooth flow of information between the two ministries.

There has to be a holistic approach between the MOH, DVO, and ZDU who played an essential role in making information available to the general population. This underlines the importance of establishing an efficient collaboration system between public and private veterinarians and public health authorities. it is important to effectively and efficiently set up reliable records for animal bites and comply with the existing regulation, including rabies vaccination of all animals.

Since there is no clinical treatment for this zoonotic disease, and only prevention by vaccination is possible public and animal health authorities such as the OIE, recommend the vaccination of domestic animals to avoid the spread of rabies. However, in Spain, mandatory legislation about animal vaccination against rabies is the responsibility of the regional administration, not the national government. Some regions require mandatory vaccination of dogs, and in some places cats are also vaccinated. In some cases mandatory vaccination is annual, in others biennial, and in some autonomous communities it is not mandatory.

The successful collaboration underlines the importance of the One Health concept in preventing emerging disease and the spread of infectious animal disease that could have a significant impact on public health, animal health and national economics (Calistri, *et al*., 2013). When working in animal health, one of the first measures is to restrict movement of susceptible animals and trade, and to review the most recent movements of the animal involved.

Educating the general population about the importance of animal vaccination could prevent a mortal disease not only of animals but also of humans, and make them participants and collaborators in providing epidemiological data when an outbreak of an emerging disease happens. It is also crucial to enhance community awareness about the risks associated with animal bites. It is relevant to note the importance of having reference laboratories with updated diagnostic assays and trained personnel who can respond to an alert within hours and provide relevant results.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Rabies is a neglected zoonosis that is often underestimated but it still remains a major public health problem and an economic burden especially to the rural poor residents. An understanding of the incidence and transmission dynamics of rabies and the distribution of animal bites (both spatial and temporal) can assist in the assessment of the risk of contracting the disease in humans. In addition, such data would be invaluable for estimating the disease burden as well as in the design of intervention measures to prevent exposure to the rabies virus. Unfortunately, such data are sketchy in most of the developing world. The costs due to rabies are likely to be considerable and are considered under the following categories: direct human costs from post-exposure treatment; indirect costs for the control of rabies in dogs; livestock losses and surveillance costs (Knobel *et al*., 2005). The direct medical costs include the biological cost (rabies vaccines and immunoglobulins) and administrative costs (materials and staff salaries). The indirect patient costs include out-of-pocket expenses for patients, such as transport costs to and from rabies-treatment centers, and loss of income while receiving treatment. Livestock losses to rabies can be significant; however, there are few published estimates of rabies incidence in livestock including the submission of specimens to Central Veterinary Laboratories for diagnosis.

The cases of animal-bites were distributed widely across Machakos County but most were concentrated in and around the Machakos (Level 5) and Kangundo (Level 4) hospitals. Most

(59%) of the human cases of animal-bites were in the age-group less than 15years with boys being more affected than girls. Majority of the bite wounds were on the lower extremities and few on the upper extremities Of the 121 cases of humans' animal-bites, only (27%) received the recommended five-dose vaccination regimen, others (38%) received three-doses, and 88% of the bite cases did not receive the antirabies vaccines from the public hospitals and had to purchase it from the local private pharmacies at a price of Ksh 900 per dose. This was an indication that PET was not easily available.

The cost of post exposure treatment was enormous and out of reach of most of the rural poor. Other than the cost of the vaccine itself, there were also transport costs to travel to hospitals (minimum 5 visits) in addition to the psychological torture of the animal-bites individuals, their families and friends. Thus, the burden of rabies in Machakos County was enormous. There study revealed that very little collaboration between the health Ministry and the veterinary department indicating that one health Approach was not being utilized in the control of rabies in the county. Of the 121 animal-bites cases, majority (75%) ignored the veterinary department and went straight to the hospitals to seek PET. Thus, there was minimum flow of information between the two ministries charged with the control of this dreadful of human diseases. The vaccination coverage in the county appeared very low; only (41.3%) of the animal-bites cases were attacked by known unvaccinated dogs and others (58.7%) by dogs of unknown vaccination status.

6.2 RECOMMENDATIONS

The study recommends the following:

1) There's a need for a holistic approach in the control of rabies in Machakos County so as to increase the vaccination coverage of the dog population to at least 70-75% as recommended by the WHO (2005). The proposed strategy by the Zoonoses Disease Unit (ZDU) for the elimination of canine rabies is a first step.

2) There is a need to improve collaboration between the Ministry of Health and the veterinary department, ZDU in the control of rabies in line with the "One Health" approach.

3) The Ministry of health should ensure develop policies and mechanisms to enhance access to affordable PET for all victims of animal-bites in the county and country.

4) The study recommends that in the control and management of rabies, one health is very at significant in reducing the number of cases of rabies in animals and humans by employing a five-prong approach:

- Enhancing participatory community communications and public awareness;
- Improving bite wound care for optimal post-exposure rabies prophylaxis;
- Mass vaccination of dogs;
- Human dog population management;
- Strengthening rabies diagnostic and surveillance capacities via infrastructure and manpower.

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APPENDICES

Appendix 1: CONSENT FORM

Topic: A SURVEY OF ANIMAL BITE INJURIES OF HUMANS AND THE ECONOMIC BURDEN OF RABIES IN MACHAKOS COUNTY, KENYA.

Investigator: Leelia Rosamond Andrews

Institution: University of Nairobi

Sponsor: Ministry of Agriculture, Liberia

Request: I request your participation in this study. The study aims to characterize animal bites of humans and assessing the economic burden of rabies in Machakos County.

The investigator will take about 15mins with you. During this time you will be asked questions concerning the circumstances surrounding the bite incidence which you will be required to respond to.

Risk and Benefits: There are no risks of whatsoever involved in this study. The study is expected to provide vital data on the size and extent of dog bites in Machakos County and the degree of cooperation between Medical and Veterinary personnel in the control of rabies in line with the One Health Philosophy. Such data will be valuable in informing policy makers on rabies control in Machakos County.

Confidentiality: Information obtained about you for this study will be highly confidential and will be used only for the purpose of the study. The results of the study may be published or disseminated without revealing your identity.

Consent: Your participation in this study is voluntary. You are free to decline to participate in the study. If you choose not to participate there will be no penalty.

Note: If you have any questions or concerns about the study, please feel free to contact:

Leelia Rosamond Andrews

P.O. Box 29053 00625, Nairobi

Cell phone: 0706350726

Email: leerandrews13@ymail.com

For any question pertaining to rights of a research participant, the contact person is:

The Secretary

Kenyatta National Hospital /University of Nairobi

Ethical Research Committee

Tel: (254-020) 2726300 Ext 44355

Email: uonknh_erc@uonbi.ac.ke

I have been explained and understood the information concerning the research study and voluntarily accept to be a part of this study.

Names: ______________________ Signature: ____________________ Date:__________________

Witness name: __________________ Signature: ___________________ Date: ______________

Appendix 2: Hospitals Questionnaire

A Survey of animal-bite injuries of humans and the burden of rabies in Machakos County

University of Nairobi

Faculty of Veterinary Medicine

Department of Public Health, Pharmacology & Toxicology, P.O. Box 29053 00625, Nairobi

Email: dept-publichealth@uonbi.ac.ke

The information obtained will be treated confidentially and will be used synonymously

Part A: General information

Date: ---------------- Hospital: ----------------- Interviewer: ------------------

PART B: Patient information

Age (Years) --------------

Sex: 1. Male 2. Female

Residence: Division -------------- Location--------------- Sub location------------ Village----------

Distance in Kilometers from home to hospital: ------------------

Bus fare (KSh) from home to hospital: ------------------------

Education level: 1. Primary 2. Secondary 3.College 4. No formal education

Part C: Information on bite

Date of bite ------------------- Date of reporting----------------

Type of exposure: 1. Laceration 2. Puncture wound 3. Scratch 4. Contact with saliva 5. Other (Please specify) ---------

Site(s) of bite: 1. Head 2. Hands 3. Legs 4. Body 5. Multiple sites 6. Other (Please specify) ----------

Local wound treatment: 1. Yes 2. No

Part D: Information on biting animal

Species: 1. Dog 2. Cat 3.Cow 4.Wild carnival (local name) -------- 5.Sheep/goat 6. Other (Please specify)--------------

Owner of animal: 1. Known 2. Unknown

Rabies vaccination status: 1. Vaccinated 2. Unvaccinated 3. Unknown

Clinical signs: 1. Aggression (biting anything) 2. Salivation 3. Red eyes 4. Paralysis 5. Other (Please specify) --

Any other known persons (their number) bitten by the same animal-------------------

Part E: Information on post exposure treatment

Post exposure treatment administration: 1. Yes 2. No

Source of vaccine 1.Available at the hospital 2. Purchased from a chemist 3. Other (Please specify)

Name of vaccine (batch no):_1. Immovax ( ) 2.Verorab ( ) 3.Rabipur ( ) 4. Other (Please specify) --------------------- ( )

Dose administered: 1. 0.5 ml 2. 1 ml 3. 0.1ml 4. Other (Please specify) ----------

Dates of administration: First dose----------- Second dose----------- Third dose------- Fourth dose---------- Fifth dose

Administration of antirabies serum: 1. Yes 2. No

Appendix 3: District Veterinary Offices Questionnaire

A survey of animal-bite injuries of humans and the burden of rabies in Machakos County

University of Nairobi

Faculty of Veterinary Medicine

Department of Public Health, Pharmacology & Toxicology, P.O. Box 29053 00625, Nairobi

Email: dept-publichealth@uonbi.ac.ke

The information obtained will be treated confidentially and will be used synonymously

Part A: General information

Date: ---------------- Veterinary Office: ----------------- Interviewer: ------------------

PART B: Patient information

Age (Years) --------------

Sex: 1. Male 2. Female

Residence: Division -------------- Location--------------- Sub location------------ Village----------

Distance in Kilometers from home to veterinary office: ------------------

Bus fare (KSh) from home to veterinary office: ------------------------

Education level: 1. Primary 2. Secondary 3.College 4. No formal education

Part C: Information on bite

Date of bite ------------------- Date of reporting----------------

Type of exposure: 1. Laceration 2. Puncture wound 3. Scratch 4. Contact with saliva 5. Other (Please specify) ---------

Site(s) of bite: 1. Head 2. Hands 3. Legs 4. Body 5.Multiple sites 6. Other (Please specify) ----------

Part D: Information on biting animal

Species: 1. Dog 2. Cat 3.Cow 4.Wild carnival (local name) -------- 5. Sheep/goat
6. Other (Please specify) --------------

Owner of animal: 1. Known 2. Unknown

Rabies vaccination status: 1. Vaccinated 2. Unvaccinated 3. Unknown

Clinical signs: 1. Aggression (biting anything) 2. Salivation 3. Red eyes 4. Paralysis 5. Other (Please specify) --

Any other known persons (their number) bitten by the same animal-------------------