RABIES INCIDENCE AND VACCINATION COVERAGE IN DOGS AND CATS IN KAKAMEGA COUNTY, KENYA

BY

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DECLARATION

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I hereby declare that the production of this thesis is my original work and has not been submitted in any other University.

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DEDICATION

This thesis is dedicated to my brother, James Ndumbi Mwangi, and family for encouraging me to undertake the study.

ABSTRACT

Title: Rabies incidence and vaccination coverage in dogs and cats in Kakamega county, Kenya

Background: Rabies vaccination coverage has been declining in Kenya, posing significant economic, animal health and public health impacts. Over 70% annual dog coverage is required for rabies elimination. Information on the status of rabies and vaccination coverage is lacking in most parts of the country but is urgently needed in the prioritization of elimination strategies.

Objectives: To determine rabies incidence, vaccination coverage and factors affecting the coverage in dogs and cats.

Methods: The Study was carried out in Kakamega County. The study design was a cross-sectional survey. Rabies cases and vaccination data were obtained from sub-county veterinary offices. The population of dogs was estimated using the dog: human ratio of 1:8 and that of cats using the cat: human ratio of 1:39. Vaccination coverage was calculated by dividing vaccination figures with the respective populations of dogs and cats. A self administered questionnaire to a census of 12 Sub-County Veterinary officers was used to identify institutional-level factors affecting vaccination coverage. MS Excel and SPSS version 20 were used in data analysis. Descriptive statistics were used to summarize data. Data were presented in tables, graphs, charts and narratives. Kruskal Wallis and Mann-Whitney tests were used to compare sub-county vaccination rates. A p-value of less than 0.05 was considered statistically significant.

Results: Incidences of 18 cases per 1,000,000 dogs and 67 cases per 1,000,000 cats were documented. The county coverage was 2.8% in dogs and 0.01% in cats. Sub-county dog coverage was significantly different. The coverage was hampered by inadequate documentation, knowledge of dog coverage, resources, promotion of public awareness, 'One Health' collaboration, cold chain and quality assurance infrastructure, high cost of vaccination, a 3-month cut off age in puppy vaccination, influx of dogs of unknown vaccination status and poor enforcement of rabies control laws.

Conclusion: Rabies incidence was low but was likely to have been under-estimated. Cat vaccination was neglected. Dog vaccination coverage was far below 70% level. Institutional-level factors negatively affected vaccination coverage.

Recommendations: Sustainable rabies surveillance and reporting are needed. Well planned, resource supported and executed annual mass vaccination of dogs and cats and regular public enlightenment programmes through 'One health' collaboration are required. Dog and cat population sizes, provision of 'free of charge' vaccination and inclusion of puppies younger than 3 months old in vaccinations are needed. Backup power supply, vaccine quality assurance and diagnostic laboratory and strict enforcement of rabies control laws are also required. More research is required to assess social factors that influence the uptake of rabies vaccination.

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OPERATIONAL DEFINITIION OF TERMS USED

'Dead end' host: Not transmittable to another host species.

Disease control: The restraining or limiting infection in occurrence or rate of increase.

Disease Elimination: Reduction of incidence of an infection in a country, continent or limited geographical area so that the disease is no longer considered a public health problem.

Herd immunity: Resistance to an infectious disease in an entire community due to immunity of a large proportion of individuals in that community to the disease.

'One Health' approach: The collaborative efforts of multiple disciplines working locally, nationally and globally to attain optimal health for people, animals and the environment.

Rabies control area: Any area which may be declared by the Director of Veterinary services by notice in the Gazette to be a rabies control area (Rabies quarantine area).

Rabies threshold density: Minimum dog density necessary for rabies persistence in an area.

Veterinary Public Health: The sum of all contributions to the physical, mental and social well being of humans through an understanding and application of veterinary science.

Zoonoses: Are infections that are naturally transmitted between vertebrate animals and human beings.

LIST OF ABREVIATIONS AND ACRONYMS

CAP	Chapter
DALYs	Disability Adjusted Life Years
IREC	Institutional Research and ethics Committee
KNBS	Kenya National Bureau of Statistics
NZD	Neglected Zoonotic Disease
PEP	Post Exposure prophylaxis
SCVOs	Sub-County Veterinary Officers
SPSS	Statistical Package for Social Scientists
US	United States
WHO	World Health Organization
ZDU	Zoonotic Disease Unit

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND INFORMATION

Canine rabies is a viral neglected zoonotic disease (NZD) of mammals that poses significant global economic, public health and animal health impacts (Swiff *et al.*, 2013). In developing countries rabid domestic dog bites transmit over 95% of the disease to humans and animals (Cleaveland *et al.*, 2006; Meslin *et al.*, 2013), making the dog the principal reservoir, host and vector of the disease. It is also transmitted via bites of other rabid domestic animals such as cats and donkeys. Non-bite exposures include inhalation of aerosolized virus, organ transplants particularly the cornea and contamination of abrasions, open wounds, mucus membranes with virus laden saliva or infectious material such as brain tissue (Kujul et *al.*, 2012). As the secretion of the saliva in an infected animal starts before the onset of clinical signs, all mammal bites are important in the epidemiology of rabies. Humans and domestic ruminants are considered 'dead end' hosts.

Some domestic cats exhibit carrier status for years (Kollataj *et al*., 2012), exposing humans to the increased risk of the disease. Cat immunization against the disease is, however, not mandatory in law in many countries of the world. As a result, their vaccination is neglected in rural areas. In developed countries, where canine rabies is eliminated, cats are more likely to develop rabies than dogs. For example, in 2007, Poland reported two times more cases of rabies in cats than dogs (Kollataj *et al*., 2012).

Though rabies is globally distributed, it is not found in Australia and Antarctica due to the presence of natural barriers like mountains and rivers as well as strict quarantine restrictions (Okonko *et al.*, 2010). Most developed countries have successfully eliminated the disease through legislation, public education and mass vaccination of dogs (Ali *et al.*, 2010). A few developing countries such as Philippines (Lapiz *et al.*, 2012) have also eliminated it. Tunisia (Touihri *et al.*, 2011), Chad (Dürr *et al.*, 2009; Kayali *et al.*, 2003) and Tanzania (Gsell *et al.*, 2012; Kaare *et.al.*, 2009) have demonstrated that the World Health Organization (WHO), (2005) recommended threshold of 70% annual dog coverage necessary for the disease elimination is achievable in Africa. However, sustainability is a growing challenge in the continent.

Its annual human mortality is estimated at 69,000 globally (Swiff *et al.*, 2013), 56% occurring in Asia and 43% in Africa (Karshima *et al*., 2013; Dzikwi *et al.* 2011). The majority of deaths (84%) occur in rural areas (WHO, 2013) and 30-50% of the affected are children less than 15 years of age (Knobel *et al.*, 2005; Cleaveland *et al.*, 2006). It kills 10,000 people in Ethiopia (Jemberu *et al.*, 2013), 1,500 in Tanzania (Sambo *et al.*, 2013; Bardosh *et al.*, 2014), over 440 in Uganda (1.26 cases per 100,000 humans) (Fevre *et al.* 2005) in a population of 34.9 million in 2014 (Uganda Bureau of statistics, 2014) and over 2,000 humans in Kenya (Zoonotic Disease Unit (ZDU), 2014) annually.

Basing on 2010 global estimates, rabies is responsible for 1.9 million (Disability Adjusted Life Years (DALYs) lost annually. These result from premature mortality, disability following adverse side-effects from nerve tissue vaccine (WHO, 2013), rabid animal bite injuries and psychological impacts.

Over 15 million people worldwide receive Post Exposure Prophylaxis (PEP) to avert the disease annually (Kollataj *et al*., 2012). As the highest expenditure in rabies control is the cost of PEP (Swiff *et al.*, 2013), rabies elimination leads to major economic and social benefits through significant reduction of the demand for the high cost of PEP and the effects of other impacts associated with the disease.

'One health' interventions in animal reservoir populations in the control of NZDs results in public health and social benefits that are more cost-effective than just intervention in humans (Molyneux *et al.,* 2011). For example, mass vaccination of dogs and cats against rabies substantially reduces human rabid dog and cat bites, lowering impacts associated with the disease. The approach has been used in the elimination of rabies in Texas (Swiff *et al.*, 2013) and Philippines in 2010 (Lapiz *et al.,* 2012). The major concern is why the approach is not prioritized in many rabies endemic areas of the world.

In Kenya, the first case of the disease was documented in a dog in 1912 and in a human in 1928. Epidemics experienced thereafter were controlled through sustained vaccination of dogs such that in 1973, the disease was virtually eliminated in the country. In 1980s, the disease spread to most parts of the country (ZDU, 2014) due to the collapse of vaccination programmes. Today, it occurs sporadically in all counties in the country. It is thus considered a re-emerging disease in Kenya.

Parenteral vaccination of dogs and cats and population management of stray dogs and cats remain the major rabies control strategies in Kenya. However, their vaccination coverage has been declining (Macharia *et al.,* 2003), thereby increasing rabies burden. This is probably because information on the status of rabies and vaccination coverage is scanty in most parts of the country. The aim of the study is to update the information for use in the up scaling of rabies control and elimination strategies.

1.2 PROBLEM STATEMENT

As a re-emerging disease, rabies impacts on human and livestock health are a growing national concern in Kenya. It kills over 2,000 humans (ZDU, 2014). In Africa, it kills 5 per 100,000 head of cattle annually (Knobel *et. al.,* 2005), translating to about 900 head of cattle deaths in Kenya (The cattle population was 17,467,774 in 2009 Population and Housing census). In a study, Kitala *et al.,* (2001) estimated that there were 860 rabid dogs per 100,000 dogs in the former Machakos district, Kenya. The incidence in cats has not been documented in the country.

Kakamega County is among the high rabies risk areas (Rabies control areas) in Kenya like its neighboring counties; Bungoma, Vihiga, Busia, Siaya, Kisumu (Rabies Act, CAP 365). Increased dog trade in the county has led to unrestricted movement of susceptible dogs. There are numerous sugar bushes and a large forest cover that are important habitats of wild canines that play an important role in rabies transmission. There is a high density of poorly supervised and inadequately immunized dogs.

In Sub-Saharan Africa, Kenya included, dog vaccination coverage is much lower than the recommended 70% (Cleaveland *et al.,* 2006). In a study in Machakos County, Kenya, Kitala *et al.,* (2001) found that 29% of dogs had been vaccinated against rabies. Cat vaccination coverage has not been documented in Kenya. Rabies incidence and burden are also under estimated by 70 times in animals and 200 times in humans (ZDU, 2014).

If the problem is not urgently addressed, rabies incidence will continue to rise. Further, the scale and magnitude of the disease burden that is necessary for the disease prioritization will be difficult to assess.

1.3 JUSTIFICATION

Rabies has no effective treatment and its case fatality rate is nearly 100%. Its incidence has been increasing across most of Sub-Saharan Africa (Kaare *et al*., 2009) despite the disease being 100% preventable through vaccination.

In humans, PEP exerts a substantial economic burden to dog and cat bite victims and their families due to high cost of vaccine, travel and loss of income. In 2012, Kenya imported 60,000 doses of human rabies vaccine for PEP costing over Kshs. 27 Million (Kiambi, 2013) thereby overburdening the health budget. Severe rabid dog bites injuries especially to the head and neck, the distressing clinical signs and the fatal outcome of the disease impact substantial psychological trauma to families, communities and health care workers (Lembo *et al.,* 2010). The death of livestock and production losses resulting from the disease have numerous social and economic implications (Okell *et al.,* 2013).

Although the vaccination of dogs and cats has been a major rabies control strategy for a long time in Kenya, the disease burden continues to rise. To reverse the situation, effective control and elimination strategies are urgently required. However, information on rabies incidence and vaccination coverage is lacking in most parts of the country.

The purpose of this study is to obtain baseline information on the status of the disease and vaccination coverage to assist in influencing the prioritization of surveillance and vaccination strategies. The immunization of dogs and cats reduces the incidence of human and animal rabid dog and cat bite injuries thereby minimizing the demand for the costly PEP and other impacts associated with the disease. Further, the results will add knowledge to the field of public health and animal health as well.

1.4 RESEARCH QUESTION

1. What is the incidence of rabies in dogs and cats?

2. What is the rabies vaccination coverage in dogs and cats?

3. What are the factors affecting rabies vaccination coverage?

1.5 OBJECTIVES

1.5.1 Broad Objective: To determine rabies incidence and vaccination coverage in dogs and cats in Kakamega County from 2009 and 2013.

1.5.1.1 Specific Objectives

1. To determine the incidence of rabies in dogs and cats.
2. To determine rabies vaccination coverage in dogs and cats.
3. To determine factors affecting rabies vaccination coverage in dogs and cats.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Zoonoses like rabies constitute about 75% of human emerging and re-emerging infections and are also twice as likely to occur as emerging diseases than non-Zoonoses (Taylor *et al.,* 2001). Their disastrous impact on human and livestock health are growing concerns worldwide (Swai *et al.,* 2010; Okonko *et al.,* 2010). Namanda, (2008) observed that expenses related to their prevention are likely to continue increasing, urgently calling for effective control and eventual elimination in animal reservoirs. The control of zoonotic diseases requires the intervention of Veterinary Public Health, whose main objective is to promote the well being and quality human life (Girma *et al.,* 2012).

Rabies is maintained in sylvatic (wildlife) and urban epidemiological cycles. The sylvatic cycle is predominant in Europe and North America. In Europe, the maintenance and transmission species are the red fox and bats. In North America, the disease is maintained and transmitted by raccoons, skunks and bats. In both regions, the two cycles occur simultaneously (Okonko et al., 2010). The urban cycle is predominant in developing countries mainly in Africa and Asia where the domestic dog accounts for over 95% of the disease in humans and animals (Meslin *et al.,* 2013).

2.2 RABIES BURDEN

Rabies annual human mortality is over 69,000 globally (Swiff *et al.,* 2013) with over 56% occurring in Asia and 43% in Africa (Karshima *et al*., 2013; Dzikwi *et al.* 2011). The burden of the disease is not distributed evenly across all sectors of the society. The majority of deaths (84%) occur in poverty stricken rural areas (WHO, 2013) and 30-50%

of the affected are children less than 15 years of age. Children are also more often bitten by rabid dogs than adults and are more bitten on the head and neck, exposing them to higher risks of the disease (Knobel *et al.*, 2005; Cleaveland *et al.*, 2006). Rabies kills over 10,000 people in Ethiopia (Jemberu *et al.*, 2013), 1,500 humans in Tanzania (Sambo *et al.*, 2013; Bardosh *et al.*, 2014), 440 in Uganda (1.26 deaths per 100,000 humans) (Fevre *et al.* 2005) in a population of 34.9 million in 2014 (Uganda Bureau of statistics, 2014) and 2,000 humans in Kenya (Zoonotic Disease Unit (ZDU), 2014) annually.

Rabies accounts for a substantial burden in humans resulting from rabid dog and cat bites which can result in severe injuries and sometimes death. According to Cleaveland *et al.*, (2006), the morbidity of dog bite injuries ranges from 40 to 288 cases per 100,000 people globally. Severe dog bites injuries especially to the head and neck, the distressing clinical signs and the fatal outcome of the disease impact substantial psychological trauma to families, communities and health care workers (Lembo *et al.*, 2010).

Basing on 2010 global estimates, the disease accounts for over 1.9 million DALYs lost annually mainly from premature mortality, severe dog bite injuries, morbidity of adverse side-effects due to nerve tissue vaccines and psychological impact of fear and trauma after a suspected rabid bite. About 12,000 DALYs lost are due to morbidity resulting from adverse effects from nerve tissue vaccine. The psychological impacts account for an estimated 140,000 DALYs lost in Asia with the Middle East being responsible for 13,100 and Central Asia 55,000 DALYs lost. Africa accounts for over 609,000 DALYs lost with Ethiopia representing about 1,000 DALYs due to widespread use of tissue culture vaccines. The psychological impacts from the disease are also substantial with Asia and Africa accounting for about 140,000 and 32,000 DALYs lost respectively (WHO, 2013).

Over 15 million people worldwide receive Post Exposure Prophylaxis (PEP) annually to avert the disease (Kollataj *et al*., 2012). The global annual estimated cost of rabies impact is 695 US (United States) Dollars (Swiff *et al.,* 2013). However, this is underestimated as the economic costs emanating from death of domestic animals other than cattle, livestock production losses and psychological impacts have not been accounted for. According to (Swiff *et al.*, 2013), PEP takes the highest expenditure in rabies control worldwide. This contradicts Wera *et al.*, (2013) finding that the cost of culling roaming dogs in Flores Island was highest at 39% as compared to PEP at 35% of total rabies control expenditure. This was attributed to the high value of culled dogs that was ignored in other studies.

The reduction of rabies incidence in dogs and cats reduces the demand for human PEP, minimizing the associated costs (Cleaveland *et al.,* 2006). However, this is not always true. Cleaveland *et al.,* (2003) observed that the disease may need to be virtually eliminated before demand for PEP decreases as documented in Tunisia and Thailand. Further, Swiff *et al.,* (2013) reported that significant reduction in human death in Latin America did not translate into lower demand for PEP. Many individuals in rabies endemic areas, who are at low risk of developing it, continue seeking PEP regardless of the recommendation by health professionals (Rupprecht *et al.,* 2010). This was likely due to inadequate awareness and the psychological impacts associated with the disease.

2.3 RABIES INCIDENCE AND VACCINATION COVERAGE

Dog vaccination is an important component in the prevention and control of rabies (Okonko *et al.,* 2010; Thomas *et al.,* 2013). Low and inconsistent coverage contribute to rabies endemicity and epidemics (Okonko *et al.,* 2010). To achieve the elimination goal, a coverage of 70% in an annual vaccination campaign is recommended (Dürr, *et. al.,* 2008; WHO 2005). Where dog turnover rates is high, 60% coverage in biannual campaigns is also effective in the elimination of the disease (Kitala *et al.*, 2002).

A study in the former Machakos district, Kitala *et al.,* (2002) found that rabies incidence decreases almost linearly with the increase in vaccination coverage and rabid dog bites also reduce significantly. In another study in Northern Tanzania conducted between 1996 and 2001, mass vaccination of dogs effectively achieved 73.7% coverage and reduced rabies incidence by 97% and dog bites by 92% (Cleaveland *et al.,* 2003). This highlights that rabies control in dog populations is a more cost-effective way to reduce rabies in humans than reliance on PEP (Kayali *et al.,* 2006; Ali *et al.,* 2010; Zinsstag *et al.,* 2009; Aworh *et al,.* 2011).

Sustainability of elimination coverage levels in dogs needs to be maintained annually to avoid rapid re-emergence of the disease. Despite rabies control in a Tanzanian site from 1998 to 2001, coverage declined in 2001 to 2003 resulting in a new rabies epidemic where human exposure increased six-fold in 2003 as compared to the previous years (Cleaveland, *et. al.,* 2006). This agrees with Etter *et al.,* (2006) observation that disinvestment in control of NZDs increases chances of disease re-emergence.

Rabies endemicity depends on threshold dog density. Knobel *et al.,* (2005) estimated the global threshold density at 9 dogs per Km^2. With a dog population growth rate of 5-10% and mobility of human populations in Sub-Saharan Africa, dog densities will increase and more areas are likely to suffer from endemicity if control measures are not proportionally stepped up (Cleaveland *et al.,* 2006).

2.4. FACTORS AFFECTING VACCINATION COVERAGE

Between annual vaccination programmes, vaccination is passively offered by both government and private veterinarians with dog and cat owners requesting for the service. There are a number of factors affecting vaccination performance that can be categorized into institutional-level factors, social and environmental factors.

In developed countries, the demand for vaccine is higher than expected resulting in shortages arising from interruptions in vaccine production and supply. In developing countries, however, lack of funds to purchase vaccines is a barrier to effective coverage (Okonko *et al.*, 2010). In a study in Tanzania, Bardosh *et al.*, (2014) found that shortages of fuel, staff, vaccines, equipment and operational funds were common in vaccination programmes, the shortage of funding being a major contributing factor. In Kisumu City, Kenya, Kagira *et al.*, (2012) found that inadequate funding negatively affected the coverage.

Cost recovery in dog vaccination remains a major challenge in developing countries. In Africa, the coverage in 'free of charge' programmes is significantly higher than that in owner 'charged' programmes. For example, in Tanzania, an owner 'charged' vaccination programme achieved 9% coverage (Cleaveland *et al.*, 2003) while a 'free of charge' programme achieved over 80% coverage (Kaare *et al.*, 2009). In Indonesia, however, the coverage remained as low as 33% in a 'free of charge' vaccination programme (Wera *et al.*, 2013). The differences were attributed to diverse levels of social factors.

A study to estimate the association between charges per dog vaccinated and coverage in Chad by Dürr *et al.*, (2008) revealed that the maximum dog owners could pay per dog and achieve 70% coverage necessary eliminate rabies was less than 0.78 US Dollars. In a study in Nigeria, Ehizibolo *et al.*, (2008) noted that the cost of vaccinating dogs was very prohibitive, negatively affecting vaccination coverage. Therefore, substantial subsidy is necessary in the achievement of 70% coverage.

Promotion of public awareness on rabies and its control measures influences vaccination performance. According to WHO, (2004), low community awareness is a major a deficiency in rabies control. In a study in India, public awareness and community participation in rabies control were found to be inadequate (Prakash *et al.,* 2012). In a study in Kisumu City, Kenya, Kagira *et al.*, (2012) found that poor public health strategies hampered the vaccination coverage. Macharia *et al.*, (2003) recommended improvement of community awareness and their active participation in rabies control strategies in Kenya.

A good knowledge of vaccination coverage among veterinary personnel is important for comparison with the WHO recommended 70% dog coverage and for continuous performance improvement. In a study in Tanzania by Bardosh *et al*., (2014) , veterinary personnel falsely documented dog coverage as over 70% instead of 50%. In Kenya too, veterinary personnel were unable to ascertain their area dog vaccination coverage in a study in Kisumu City (Kagira *et al*., 2012) probably because of inadequate documentation of dog population.

The level of 'One health' collaboration and coordination in rabies control activities is critical especially in the promotion of public education and dog and cat population management where disposal of carcasses of baited animals needs public health action.

Where 'One health' approach has been adopted, the control and elimination of rabies has been successful; Texas (Swiff *et al.*, 2008; Swiff *et al.*, 2013), Philippines (Lapiz *et al.*, 2012). In a study in Nigeria, Ehizibolo *et al.*, (2008) recommended that 'One health' be strengthened to make rabies control programmes very effective.

A 3-month cut off age has been adopted as a policy in many countries of the world (Kaare *et al.*, 2009). For this reason, rabies vaccines are generally licensed and approved for vaccination of dogs younger than 3 months of age. Considering that the proportion of this cohort of young dogs is over 30% of the total dog populations in Africa (Lembo *et al.*, 2010; Gsell *et al.*, 2012), their exclusion significantly lowers vaccination coverage. The exclusion is unwarranted as studies have shown that such puppies can be safely vaccinated without the interference of maternal derived antibodies Furthermore, those with no passive immunity develop protective antibody titers after vaccination as early as 4 weeks of age (Lembo *et al*., 2010).

In a study in the former Machakos district, Kenya, Kitala *et al.*, (2002) observed that introduction of susceptible dogs between vaccination programmes increases the population of unimmunized dogs, lowering vaccination coverage. Most affected by introduction of dogs are countries of West Africa like Nigeria where both local and trans-boundary dog trade thrives, resulting in increased rabies incidence (Ajoke *et al.*, 2014).

Unimmunized puppies born between vaccination programmes increase dog populations. High turnover of immunized dogs between vaccination programmes reduce the population of immunized dogs. The coverage could be improved through bi-annual vaccination campaigns (Kitala *et al.*,2002). Cleaveland *et al.*, (2006) observed that in

1970s, 1980s and 1990s, there was a growing rabies problem in parts of sub-Saharan Africa and Asia resulting from rapid dog population growth (5-10%), increased urbanization, density and mobility of human populations. This is because the dog population increase lowered population immunity level thereby increasing rabies incidence.

Infrastructural factors include availability of office space, cold chain and vaccine quality assurance laboratory. Where cold chain is unavailable, vaccine accessibility is affected and vaccine quality may not be guaranteed due to poor handling. This negatively affects the effectiveness of vaccination. In a study in Nigeria, Oladokun *et al.*, (2010) found that rabies vaccine that had been initially viable and potent lost viability after one year and recommended that vaccine effectiveness be regularly checked.

In most developing countries, rabies is not effectively controlled because of lack of adequate laws, strategies and policies (Okonko *et al.*, 2010). In Poland, Kollataj *et al.*, (2012) found that cat vaccination coverage was low due to deficiencies in law. Kenya has adequate rabies prevention, control policy and regulatory laws; Animal Diseases Act (CAP 364), Rabies Act (CAP 365) and Public Health Act (CAP 242) as well as Local Authority by-laws on Animal Control. Dog vaccination and confinement are compulsory in rabies control areas (Rabies Act, CAP 365) but vaccination coverage remains low. In a study in Nigeria, Ehizibolo *et al.*, (2008) recommended enforcement of leash laws to minimize incidence of rabies.

Social factors have been associated with dog vaccination coverage. For example, in nomadic and pastoral community areas parenteral vaccine accessibility is low. Oral vaccination is an alternative in increasing coverage as it is logistically easier and inexpensive (Cleaveland *et al.,* 2006). Low socio-economic status reduces ability of dog owners to pay for vaccination services hence lowers the overage. For this reason, Kagira *et al*., (2012) recommended in a study in Kisumu City, Kenya, that the veterinary department should consider providing free dog vaccination to impoverished populations. Other social factors that could lower coverage include human demographic factors, dog ownership, knowledge and level of information about the disease, attitude and practices towards rabies vaccination, among others.

Distance from office and between vaccination centres, ease of handling dogs, vaccine and vaccine factors, increasing human activities involving dogs like hunting, trade, security, slaughter, sports among others are also important factors affecting the coverage.

2.5 CONCEPTUAL FRAMEWORK

The conceptual framework (Figure 2.1) illustrates the interplay among factors influencing dog and cat rabies vaccination coverage. The direction of the arrows shows factors influenced in each case. According to the model, institutional-level factors (dependent variables) influence the utilization of dog and cat rabies vaccination (intervening variable) which eventually influences vaccination coverage (Outcome variable).

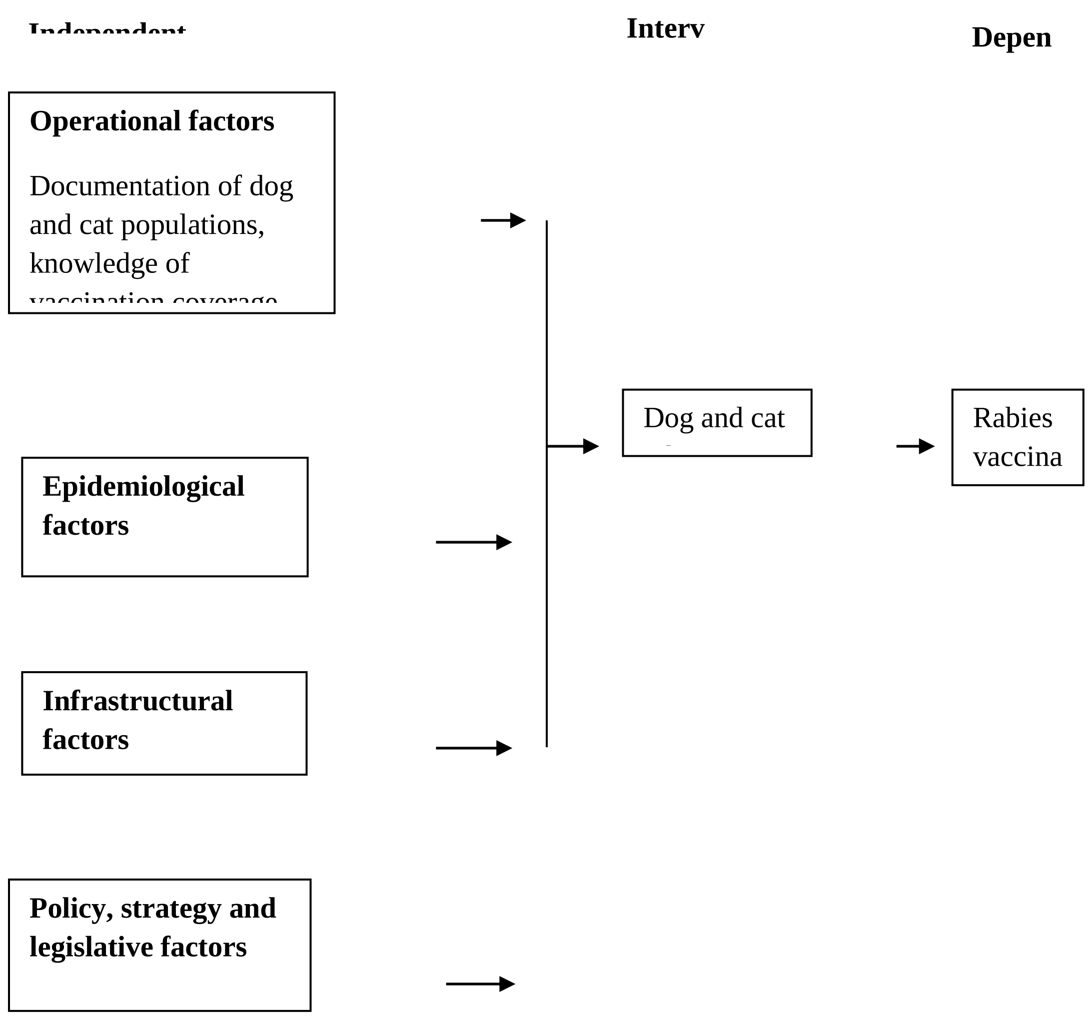

Figure 2.1 Conceptual Framework

Source: Developed by the researcher.

CHAPTER 3: METHODS

3.1 STUDY AREA

The study area was Kakamega County. It has 12 sub-counties. It borders Uasin Gishu, Nandi, Vihiga, Siaya, Busia, Bungoma and Trans Nzoia Counties. It is located on Latitudes 0.2753652 North and Longitudes 34.75705149 East in the map of Kenya. The total area is 3,051 Km^2. The human population was 1,660,651 with an annual growth rate of 2.48%, a density of 544 persons per Km^2 and had 398,709 households (Kenya 2009 Population and Housing census). Its economic drivers are trade, sugarcane and maize farming.

The county was purposively selected since it is among the high risk rabies areas in Kenya (rabies control areas). It has numerous sugar bushes and a large forest cover that are habitats of wild dogs and cats that are important in the epidemiology of rabies. It has 7 active dog markets. The dog trade has increased the risk of rabies spread due to increased movement of many unimmunized dogs. The distribution of dog markets, sugar bushes and a forest cover per sub-county is shown in Table 3.1. In the county map (Figure 3.1), Khwisero, Matungu, Matete, Likuyani and Navakholo Sub-Counties are missing as they were created after the map was developed.

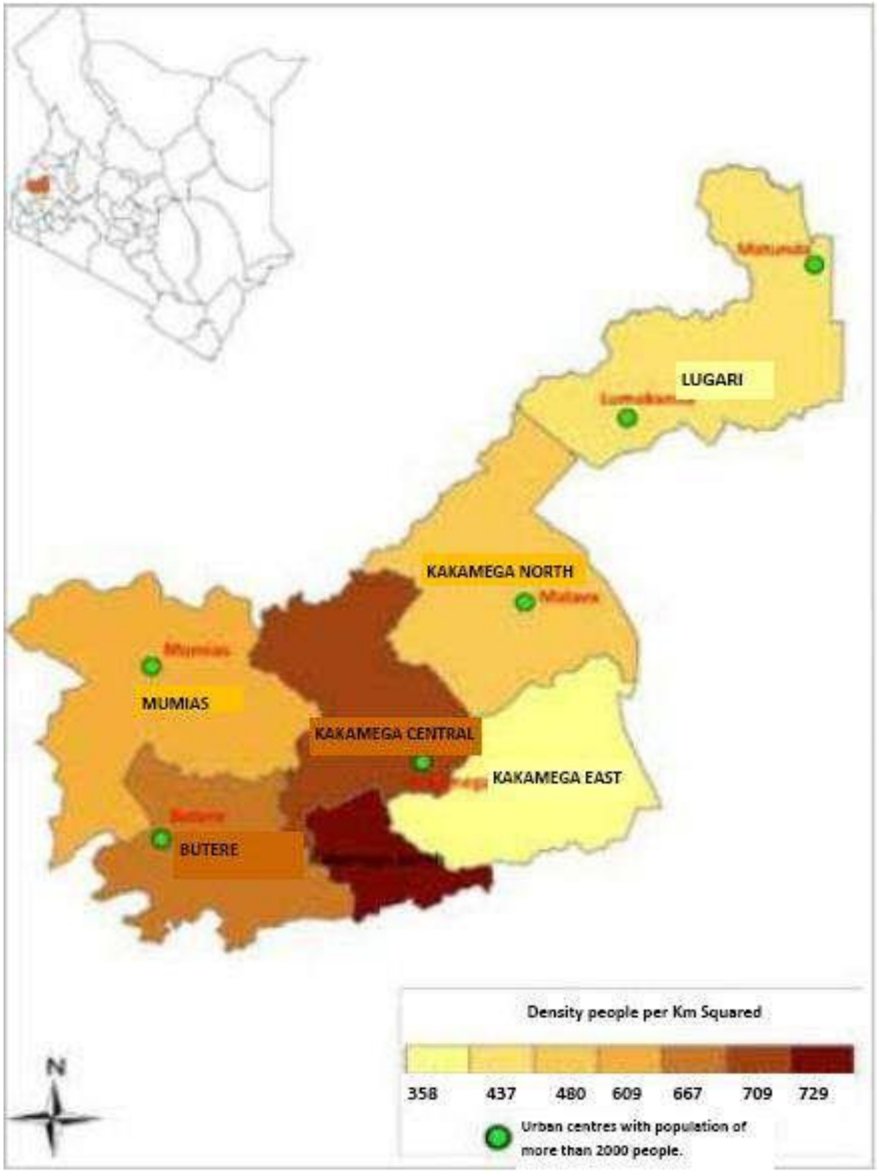

Figure 3.1: Kakamega County Map

Source: Adopted from en.wkipedia.org/wiki/kakamega_county

Table 3.1 Distribution of dog markets, sugar bushes and forest cover

Sub-county	Dog market	Sugar bushes	Large forest cover
Lugari	×	×	×
Khwisero	×	×	×
Likuyani	×	×	×
Ikolomani	✓	×	×
Matungu	×	✓	×
Butere	×	✓	×
Lurambi	×	✓	×
Mumias	×	✓	×
Matete	✓	✓	×
Navakholo	✓	✓	×
Shinyalu	✓	×	✓
Malava	✓	✓	✓

Source: Developed by researcher

Key

× - Absent

✓ - Present

3.2 STUDY POPULATION

The Sub-County Veterinary officers (SCVOs) were the targeted group for collection of data on rabies incidence, vaccination coverage in dogs and cats and also in the determination of factors affecting the coverage in Kakamega County. The census of dogs and cats had not been carried out in Kenya. The dog population was estimated using dog: human population ratio of 1:8 (Kitala *et. al.*, 2001: Ratsitorahina, *et. al.*, 2009). Since the cat: human population ratio in Kenya is unknown, it was calculated using the cat population of 1,000,000 obtained by Broad, (2013) and human population of 38,610,097 in 2009 (2009 Population & Housing census). The calculated ratio of 1:39 was used to estimate the cat population in the study. The human population and the estimated dog and cat population per sub-county are summarized in Tables 3:2, 3:3 and 3:4 respectively. The county mean annual population of dogs was 218,392 while that of cats was 44,773.

Table 3:2 Human population per sub-county

Year/ Sub-county	**2009**	**2010**	**2011**	**2012**	**2013**
Lugari	106,123	108,788	111,519	114,320	117,190
Khwisero	102,635	105,212	107,854	110,562	113,339
Ikolomani	104,669	107,297	109,991	112,753	115,585
Matungu	146,563	150,243	154,016	157,883	161,848
Butere	139,780	143,290	146,888	150,576	154,357
Mumias	212,818	218,162	223,640	229,256	235,012
Matete	60,891	62,420	63,987	65,594	67,241
Lurambi	160,229	164,252	168,377	172,605	176,939
Shinyalu	159,475	163,479	167,584	171,792	176,106
Malava	205,166	210,318	215,599	221,013	226,562
Navakholo	137,165	140,609	144,140	147,759	151,470
Likuyani	125,137	128,279	131,500	134,802	138,187
Total	1,660,651	1,702,349	1,745,095	1,788,915	1,833,836

Source: Kenya National Bureau of Statistics, Kakamega.

Table 3:3 Dog population estimates per sub-county

Year/ Sub-county	2009	2010	2011	2012	2013
Lugari	13,265	13,599	13,940	14,290	14,649
Khwisero	12,829	13,152	13,482	13,820	14,167
Ikolomani	13,087	13,412	13,749	14,094	14,448
Matungu	18,320	18,780	19,252	19,735	20,231
Butere	17,473	17,911	18,361	18,822	19,295
Mumias	26,602	27,270	27,955	28,657	29,377
Matete	7,611	7,803	7,998	8,199	8,405
Lurambi	20,029	20,532	21,047	21,576	22,117
Shinyalu	19,934	20,435	20,948	21,474	22,013
Malava	25,646	26,290	26,950	27,627	28,320
Navakholo	17,746	17,576	18,018	18,470	18,934
Likuyani	15,642	16,035	16,438	16,850	17,273
Total	208,184	212,795	218,138	223,614	229,229

Source: Developed by the researcher from Table 3.2 using dog: human ratio of 1:8.

Table 3.4 Cat population estimates per sub-county

Year/Sub-county	2009	2010	2011	2012	2013
Lugari	2,721	2,789	2,859	2,931	3,005
Khwisero	2,632	2,698	2,765	2,835	2,906
Ikolomani	2,684	2,751	2,820	2,891	2,964
Matungu	3,758	3,852	3,949	4,048	4,150
Butere	3,584	3,674	3,766	3,861	3,958
Mumias	5,457	5,594	5,734	5,878	6,026
Matete	1,561	1,601	1,641	1,682	1,724
Lurambi	4,108	4,212	4,317	4,426	4,537
Shinyalu	4,089	4,192	4,297	4,405	4,516
Malava	5,261	5,393	5,528	5,667	5,809
Navakholo	3,517	3,605	3,696	3,787	3,884
Likuyani	3,209	3,289	3,372	3,456	3,543
Total	42,581	43,650	44,744	45,867	47,022

Source: Developed by the researcher from Table 3.2 using cat: human ratio of 1:39

3.3 STUDY DESIGN

A descriptive cross-sectional survey was used in the study.

3.4 SAMPLE SIZE DETERIMINATION

A census method was used in the study. All the 12 SCVOs working in the county in the period 2009 to 2013 and whole populations of dogs and cats were used in the study.

3.5 ELIGIBILITY CRITERIA

3.5.1 Inclusion criteria

SCVOs who had worked in the county in the period 2009 to 2013 and consented to taking part in the study.

3.5.2 Exclusion criteria

SCVOs who had not worked in the county in the period 2009 to 2013 and those who did not offer consent to taking part in the study.

3.6 DATA COLLECTION

3.6.1 Data collection tools

Self administered questionnaires to SCVOs (Appendix 2) were used to collect information on factors affecting vaccination coverage.

3.6.2 Pre-test

The questionnaire was pre-tested in Bungoma County by 6 out 7 SCVOs. The purpose of the pre-test was to clarify any ambiguities, answers or any other related questions in the questionnaire. Comments from the respondents were also used to revise questions that were not clear.

3.6.3 Data collection procedure

Upon consenting to taking part in the study, the respondents provided secondary data on annual incidence of rabies and vaccination figures of dogs and cats from their annual reports for the years 2009 to 2013. They also filled the questionnaires that required information on operational, epidemiological, infrastructural and legislative factors affecting vaccination coverage. To minimize low return rate, the researcher collected the completed questionnaires and secondary data at a time specified by the respondents. The vaccination coverage was calculated by dividing the vaccination figures with the respective dog and cat populations and then expressed as a percentage.

3.7 DATA PRESENTATION AND ANALYSIS

Data were cleaned by checking for completeness and consistency that could affect the analysis. Microsoft excel spreadsheet and the Statistical Package for Social Scientists (SPSS) version 20 computer softwares were used for data analysis. Descriptive statistics (frequencies, proportions, mean and range) were used to summarize data. Data was presented in tables, graphs and charts and narratives. Kruskal-Wallis and Mann-Whitney tests were used to compare differences in means of sub-county dog vaccination coverage. A p-value of less than 0.05 was considered significant.

3.8 ETHICAL CONSIDERATION

Ethical clearance was obtained from the Institutional Research and Ethics Committee (IREC) of Moi University (Appendix 4). A written authority was obtained from the County Director of Veterinary services before commencement of the study (Appendix 5). The purpose of the study was explained and signed informed consent sought before the participants were included in the study (Appendix 1).

3.9 LIMITATION OF THE STUDY

The actual dog and cat populations were unknown hence were estimated and used in the calculation of the respective dog and cat vaccination coverage. The study was also limited to institutional-level factors.

CHAPTER FOUR: RESULTS

4.1 INTRODUCTION

The study was conducted from August, 2014 to October, 2014. The return rate for the questionnaire was 100%. Rabies incidence and vaccination figures were available in all the sub-county veterinary offices. Vaccination coverage was obtained by dividing vaccination figures with the respective dog and cat populations and then expressing it as a percentage. The findings are presented by graphs, tables, charts, percentages and inferential statistics.

4.2 RABIES INCIDENCE

A total of 7 cases of rabies (4 in dogs and 3 in cats) were reported in the period 2009 to 2013. This translates to an incidence of 18 rabid dogs per 1,000,000 dogs (4 cases/218,392 dogs) and 67 rabid cats per 1,000,000 cats (3 cases/44,773 cats). No cases were reported in the years, 2011 and 2012. Of the 7 cases, 3 cases in dogs and 3 in cats were reported in sub-counties having dog markets and sugar bushes (Matete and Navakholo) while 1 case in a dog was reported in a sub-county having no dog markets, sugar bushes and forest cover (Likuyani).

4.3 ANNUAL VACCINATION COVERAGE

The analysis of vaccination coverage was undertaken to assess the performance of rabies vaccination programmes. The annual dog vaccination figures are presented in Table 4.1. The blank space in the table indicates undocumented data.

Table 4.1 Annual dog vaccination figures

Year/ Sub-county	2009	2010	2011	2012	2013	Total
Lugari	248	87	355	360	540	1,590
Khwisero	274	382	350	316	325	1,647
Ikolomani	449	461	470	487	458	2,325
Matungu	211	215	385	347	250	1,408
Butere	681	550	152	165	151	1,699
Mumias	760	629	574	1,060	650	3,673
Matete	743	627	701	846	502	3,419
Lurambi	559	613	1,368	1,200	1,563	5,303
Shinyalu	830	212	264	261	950	2,517
Malava	221	-	1,140	260	1,578	3,199
Navakholo	292	280	296	277	315	1,460
Likuyani	594	460	1,070	682	131	2,937
Total	**5,862**	**4,516**	**7,125**	**6,261**	**7,413**	**31,177**

Source: Sub-County Veterinary Officers, Kakamega

The annual dog vaccination coverage is illustrated in Table 4.2. The missing data (blank space) was excluded from the analysis. The county annual mean dog vaccination coverage was 2.8% and the sub-county annual mean coverage ranged from 1.5% to 8.6%. When compared with the WHO recommended 70% annual coverage, the county and all the sub-counties' performances were significantly low. There were slight fluctuations in the county coverage, the highest being 3.3% in 2011 followed by 3.2% coverage in 2013.

Table 4.2 Annual dog vaccination coverage (%)

Year/ Sub-county	2009	2010	2011	2012	2013	Mean
Lugari	1.9	0.6	2.5	2.5	3.7	2.2
Khwisero	2.1	2.1	2.6	2.3	2.3	2.3
Ikolomani	3.4	3.4	3.4	3.5	3.2	3.4
Matungu	1.2	1.1	2.0	1.8	1.2	1.5
Butere	3.9	3.1	0.8	0.9	0.8	1.9
Mumias	2.9	2.3	2.1	3.7	2.2	2.6
Matete	9.8	8.0	8.8	10.3	6.0	8.6
Lurambi	2.8	3.0	6.5	5.6	7.1	5.0
Shinyalu	4.2	1.0	1.3	1.2	4.3	2.4
Malava	0.9	-	4.2	0.9	5.6	2.3
Navakholo	1.6	1.6	1.6	1.5	1.7	1.6
Likuyani	3.8	2.9	6.5	4.0	0.8	3.6
County mean coverage	2.8	2.1	3.3	2.8	3.2	2.8

Source: Developed by the researcher by dividing dog vaccination figures (Table 4.1) by dog population (Table 3.3) and then expressing it as a percentage.

In making sub-counties' mean dog vaccination coverage comparison using the Kruskal Wallis test analysis, the 12 sub-counties differed significantly on their coverage ($p<0.05$). Considering the mean ranks, Matete Sub-County scored the highest (56.40), followed by Lurambi (45.00). Matungu (14.20) scored the lowest (Table 4.3).

Table 4.3: Comparison of sub-counties' mean vaccination coverage

Sub-county	N (No of ranks)	Mean rank
Matete	5	56.40
Lurambi	5	45.00
Likuyani	5	35.90
Ikolomani	5	30.00
Mumias	5	29.60
Khwisero	5	27.50
Malava	4	27.50
Shinyalu	5	25.70
Lugari	5	24.10
Butere	5	18.60
Navakholo	5	16.00
Matungu	5	14.20
Total	**59**	

$P = 0.003 < 0.05$, $H = 28.470 > 19.675$, df=11

Source: Developed by the researcher from Kruskal Wallis test analysis of sub-county dog vaccination coverage

To know where the difference was significant, each of all the possible 65 pairwise comparison of the sub-counties was carried out using Mann-Whitney test (Table 4.4 in appendix 3). From the analysis, Matete Sub-county was significantly better in dog coverage than all the other sub-counties followed by Lurambi that was better than 5 sub-counties, Ikolomani better than 3, Khwisero and Mumias better than 2 other sub-counties each ($p<0.05$). The following sub-counties was not significant in all comparisons:- Matungu, Navakholo, Butere, Shinyalu, Malava, Likuyani and Lugari

Cat vaccination was reported by Matete Sub-County only; 6 cats in 2009, 5 in 2010, 1 in 2011, 4 in 2012 and 4 cats in 2013. The county coverage was 0.01% in 2009, 0.01% in 2010, 0.002% in 2011, 0.01% in 2012 and 0.01% in 2013. The county annual mean cat coverage was 0.01%.

A comparison of dog and cat vaccination coverage shows that dog coverage was significantly higher than cat coverage (Figure 4.1).

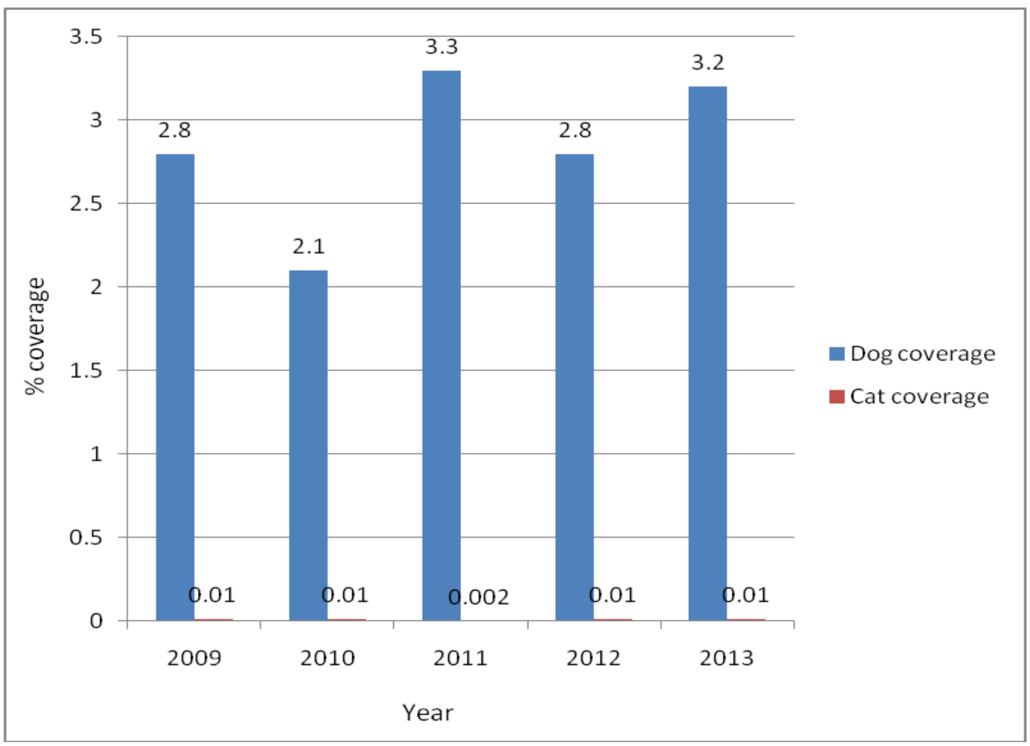

Figure 4.1 Comparison of dog and cat vaccination coverage

4.4 FACTORS AFFECTING VACCINATION COVERAGE

4.4.1 Operational factors

4.4.1.1 Documentation of dog and cat populations

Documentation of dog and cat population is needed for planning effective vaccination programmes and the calculation of vaccination coverage. The study showed that there was inadequate documentation of dog and cat populations in the county as none of the respondents used the population data in planning for vaccinations. All the 12(100%) respondents used past vaccination records in the planning.

4.4.1.2 Knowledge of vaccination coverage

Knowledge of dog coverage is important for continuous appraisal and improvement towards the required 70%. In the rating of dog coverage, 9(75%) indicated it as fair, 1(8.3%) as good and 2(16.7%) as poor. When county coverage dog coverage (2.8%) is compared with the ideal 70%, the rating as fair shows the respondents had inadequate knowledge of the dog coverage. Of the 12 respondents, 10 (83.3%) rated cat coverage as negligible, 1(8.3%) as poor and 1(8.3%) as fair. Considering that the county coverage was 0.01%, the study showed that the SCVOs had knowledge of the cat coverage.

4.4.1.3 Availability of resources

The study showed shortages of resources was a limiting factor to vaccination performance as each of the 12(100%) respondents experienced shortages of more than one resource. Considering each factor at a time, inadequate funding was identified by all the 12(100%) respondents, inadequate transport by 10(83.3%) and 9(75%) respondents as important resource factors negatively affecting the coverage (Table 4.5).

Table 4.5 Resource factors affecting vaccination coverage

Resource factor	Frequency	percent	Cumulative percent
Inadequate funds, transport and vaccine	3	25.0	25.0
Inadequate funds, transport, technical personnel	2	16.7	41.7
Inadequate funds, transport, technical personnel and vaccine	2	16.7	58.4
Inadequate funds and vaccine	2	16.7	75.0
Inadequate funds and transport	1	8.3	83.3
Inadequate funds, transport, vaccine and equipment	1	83.3	91.7
Inadequate funds, transport, vaccine, technical personnel and equipment	1	8.3	100
Total	12	100	

4.4.1.4 Cost of vaccination

The study showed that all the 12(100%) respondents charged for dog/cat as well as livestock vaccination and held joint programmes for them. In government supported vaccination programmes, the majority 10(83.3%) of the respondents charged Kshs. 100 while 2(16.7%) (Butere and Mumias) charged Kshs. 50 per dog/cat.

The county coverage (2.8%) obtained in owner 'charged' vaccination programme (Kshs. 100 per dog/cat) was significantly lower than 68% point estimate from 'free of charge' dog vaccination for Africa reported by Jibat *et al.*, (2015).

From pairwise comparisons, (Table 4.4 in Appendix 3) all sub-counties charging Kshs 100 significantly performed better than Butere while 9 performed better than Mumias.

4.4.1.5 Promotion of public awareness

The promotion of public awareness on rabies and its control measures is expected to have positive influence on vaccination performance in rabies endemic areas. The study showed that the majority 8(66.7%) of the respondents did not carry out promotion of public awareness. The remaining 4(33.3%) respondents in Lugari, Lurambi, Shinyalu and Mumias that used public barazas and field days as forums for their promotion campaigns. Print media and radios/TVs were not used in the promotion.

From sub-county pairwise comparisons (Table 4.4 in Appendix 3), Matete was significantly better in performance than all the 4 sub-counties that carried out the promotion ($p<0.05$). There was no statistical difference in performance when Lugari and Shinyalu were compared with the other 7 sub-counties. Likewise, no difference was found when Lurambi was compared with 4 sub-counties (Ikolomani, Malava, Butere and Shinyalu) and Mumias with 5 sub-counties (Khwisero, Ikolomani, Butere, Shinyalu and Malava) that did not promote the awareness.

4.4.1.6 'One Health' collaboration

The collaboration of veterinary and medical professionals was low in the county as 6(50%) respondents rated the collaboration as fair, 5(41.7%) as poor and only 1(8.3%) as excellent. The county coverage (2.8%) was significantly lower than the required 70% dog coverage achieved in 'One Health' planned and implemented programmes in Texas (Swiff, *et. al.*, 2013) and in Philippines in 2010 (Lapiz *et. al.*, 2012).

4.4.2 Epidemiological factors

4.4.2.1 Minimum age for dog vaccination

The study shows that puppies less than 3 months of age were generally excluded from vaccinations (Table 4.6). The minimum age for starting the vaccination ranged from 2 to 6 months with 6(50.0%) of the respondents starting the vaccination at 3 months of age. Of the other 6 respondents, 5(41.7%) started it later than 3 months and 1(8.3%) at 2 months of age (Shinyalu). From pairwise comparisons of sub-counties' performances (Table 4.4 in appendix 3), Shinyalu's performance was not significant despite starting vaccination of puppies at 2 months of age.

Table 4.6 Minimum age for dog vaccination

Minimum age for vaccination	Frequency	Percent	Cumulative Percent
2 months	1	8.3	8.3
3 months	6	50.0	58.3
4 months	2	16.7	75.0
6 months	3	25.0	100.0
Total	12	100.0	

4.4.2.2 Dog trade factors

The study showed that 5 of the 12 (41.7%) sub-counties had a total of 7 dog markets and that over 206 dogs were introduced into the county per week (10,712 dogs per year) from Uasin Gishu, Marakwet and Nandi Counties. Further, all the 5(100%) respondents indicated that the vaccination status of dogs presented in the markets was undocumented.

The study further showed that about 5% of the dogs presented for sale were vaccinated in the markets.

4.4.3 Infrastructural factors

4.4.3.1 Availability of cold chain

The study revealed that 11(91.7%) respondents had cold chain in their offices while 1(8.3%) respondent who had none preserved vaccine in the nearby health facility that had an alternative source of power. All the 11(100%) respondents lacked alternative power supply (generators) for use during electricity power interruptions. They employed various methods of preserving the vaccine during power interruptions: - 4(36.4%) used cool boxes, 2(18.2%) borrowed fridges, 1(9.1%) personal fridge and 1(9.1%) used a deep freezer while 3(27.3%) did nothing to preserve the vaccine (Figure 4.2).

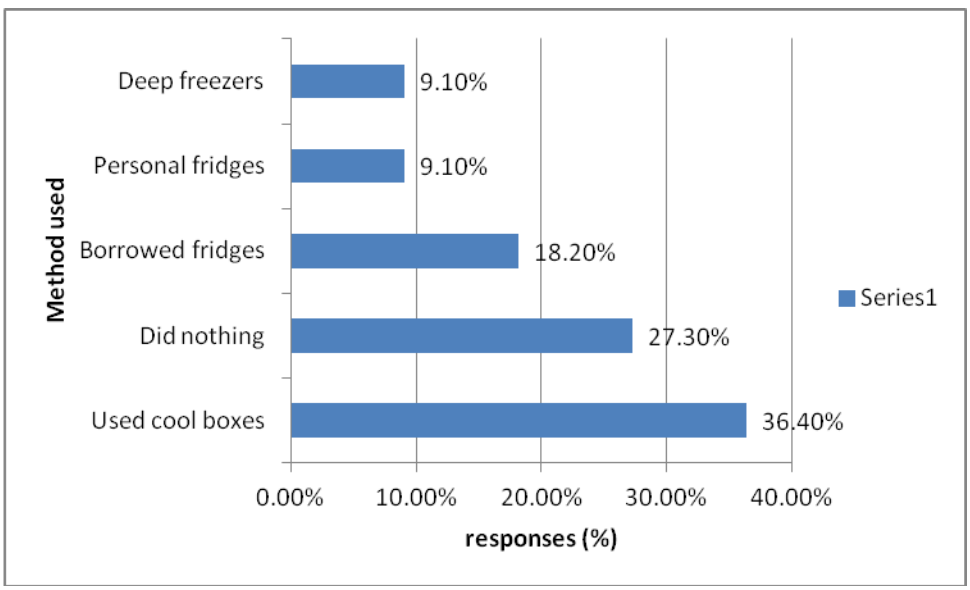

Figure 4.2 Alternative methods of preserving vaccines

4.4.3.2 Vaccine quality assurance

All the 12(100%) respondents never tested the vaccine for viability. Various reasons were given for the failure to carry out the test. The single most important reason for the failure, as indicated by 5 of 12 (41.7%) respondents, was that laboratories (Labs) were far away (Table 4.7).

Table 4.7 Reasons for failure to test for vaccine quality

Reason	Frequency	Percent	Cumulative percent
Testing labs were far away and insufficient funds	3	25.0	25.0
Unaware of testing facilities	3	25.0	50.0
Testing not routine	3	25.0	75.0
Testing labs were far away	2	16.7	91.7
Kept vaccine for immediate use	1	8.3	100
Total	12	100	

4.4.4 Policy, strategy and legislative related factors

4.4.4.1 Enforcement of rabies control laws

The study showed that enforcement of the laws was insufficient as all the 12(100%) respondents neither prosecuted dog vaccination defaulters nor dog owners for failure to confine dogs. The majority 10(83.3%) of the respondents indicated that dogs were moved into their areas of jurisdiction illegally while 2(16.7%) said the movement was sometimes legalized.

Further, the majority 9(75%) of the respondents indicated that they never authorized dog movement at all while 3(25%) respondents sometimes did (Figure 4.3).

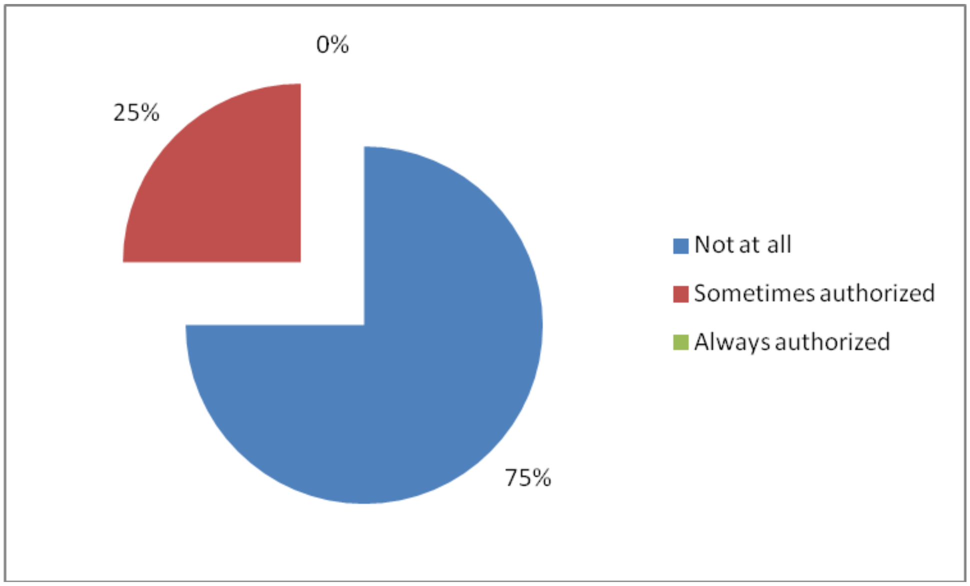

Figure 4.3 Authorization of dog movement

CHAPTER 5: DISCUSSION

5.1 RABIES INCIDENCE

As dogs and cats are the major transmitters of rabies, the incidence of the disease in their respective populations determines the amount of disease in humans and other animals. In the study, rabies incidence was low. However, it confirmed the continuing rabies endemicity in Kenya. The incidence was, however, likely to have been under-reported. This is attributable to lack of an effective surveillance system in Kenya (ZDU, 2014). In developing countries, official incidence data is limited (Kagira *et al.*, 2012) as most cases are not reported to veterinary authorities. Lembo *et al.*, (2010)

The incidence of rabies in dogs (18 cases per 1,000,000 dogs) is significantly lower than 8,600 cases per 1,000,000 dogs obtained by Kitala *et al.*, (2001) in a study in Machakos district, Kenya and 4,128 cases per 1,000,000 dogs obtained by Jemberu *et al.*, (2013) in a study in North Gondar Zone, Ethiopia. This could be explained by differences in spatio-temporal distribution of the disease and the fact that this study was limited to office data while the two studies were community based that included unrecorded cases of rabies. The incidence of the disease in cats was also low. This is not related to previous studies.

Rabies surveillance in the county was mainly passive. This could be attributed to inadequate funding support. In a previous study, Jemberu *et al.*, (2013) based their study on clinical observation without laboratory confirmation. According to Reta *et al.*, (2014), estimating rabies incidence basing on clinical diagnosis in endemic areas could not much compromise the reliability of rabies incidence as rabies symptoms and fatality are obvious to veterinary professionals.

Of the 7 cases of rabies reported in the study, 6 (3 in dogs and 3 in cats) were reported in sub-counties having both dog markets and sugar bushes. It is likely that a relationship exists between dog trade and incidence of rabies. The findings are consistent with a previous study in Nigeria by Ajoke *et al.*, (2014) who found that dog trade is an important factor in the epidemiology of rabies.

5.2 RABIES VACCINATION COVERAGE

It is impractically to vaccinate the entire human and domestic mammal populations. The most cost effective strategy for protecting them is by eliminating rabies in dog and cat populations through vaccination (Zinsstag *et al.*, 2009; Isek *et al.*, 2013; Jibat *et al.*, 2015). Further, a vaccination campaign that achieves less than 30% coverage in dogs is ineffective and a waste of resources (Lembo *et al.*, 2010). The county dog coverage (2.8%) was far below the herd immunity level (70% coverage) hence could not control rabies. The findings agree with 4% in Nairobi (Kagira *et al*., 2012), 2.8% (2006) and 2.6% (2007) in Philippines (Lapiz *et al.*, 2012) and less 5% in Far East Asia (Okonko *et al.*, 2010) found in previous studies. However, the findings differ with 35% coverage in a study in the county by Mucheru *et al*., (2014). The discrepancy could be attributed to the fact that this study was limited to office data while the other study was a household survey that included unreported data from veterinary private practitioners.

There was a significant difference in mean dog coverage among sub-counties with Matete Sub-County performing best in the coverage. The sub-County has both a dog market and sugar bushes. The presence of wild dogs in the sugar bushes and increased introduction of dogs resulting from trade are likely to influence the coverage as communities respond to increased risk of rabies through dog vaccination.

Cat vaccination coverage mean of 0.01% was negligible. It was much less than that of dogs probably because of the emphasis put on dog vaccination and inadequate public awareness on the importance of cat vaccination. The finding, however, differs with 19.8% cat coverage Poland (Kollataj *et al.,* 2012). The difference could be attributed to higher public awareness on the importance of cat vaccination in Poland.

Low coverage results in high incidence of rabies. However, in this study, both coverage and rabies incidence were low. The contradiction could be attributed to under reporting of the latter.

5.3 FACTORS AFFECTING VACCINATION COVERAGE

5.3.1 Operational factors

5.3.1.1 Documentation of dog and cat populations

Knowledge of dog and cat demography is essential important in effective planning and assessment of vaccination coverage. In the study, dog and cat populations data were not used in the planning for dog and cat vaccination against rabies, an indication that their populations are not well documented in the county. The findings are similar to a previous study by Bardosh *et al.,* (2014) who found that dog population in Ulanga and Kilombero districts in Tanzania was not well documented.

5.3.1.2 Knowledge of coverage

Knowledge of dog coverage is important for comparison with the WHO recommended 70% coverage and for continuous performance improvement in vaccination programmes. The study showed that the respondents were unaware of their area dog coverage. The findings are consistent with a previous study in the neighboring Kisumu City where veterinary staff could not ascertain their area vaccination coverage (Kagira *et al*., 2012) and a study in Tanzania by Bardosh *et al*., (2014) where official dog vaccination rate was falsely documented as higher than 70% but was actually much lower (75% in Kilombero instead of 50%). Poor knowledge of coverage negatively affects coverage due to lack of baseline data.

Respondents were aware of a negligible cat coverage probably because no cats were available for vaccination in 11 sub-counties during the study period.

5.3.1.3 Availability of resources

The availability of resources are important for successful vaccination programmes. Inadequate resources, mostly funding, were identified as obstacles to vaccination performance. This is in agreement with a study in Tanzania by Bardosh *et al.,* (2014) who found that shortages of fuel, staff, vaccines, equipment and operational funds were common in vaccination programmes with shortage of funding being a major contributing factor. According to Okonko *et al.*, (2010), rabies control in developing countries is ineffective partly because of inadequate funding.

Rabies incidence and burden are also under estimated by over 70 times in animals and 200 times in humans (ZDU, 2014). This could have contributed to low priority for rabies control in the county hence inadequate resources.

5.3.1.4 Cost of vaccination

Cost-recovery in vaccination promotes sustainability of vaccination programmes and encourages responsible dog ownership. However, it is likely to be counter-productive, resulting in low turnout and coverage.

In the study, charging for dog/cats and livestock vaccination and holding joint programmes for them was common in the county. Joint programmes reduce ability to pay for all the animals. When money is a limiting factor, livestock owners are likely to prefer livestock vaccination because dogs and cats are not considered economically valuable species in Kenya.

In the study, the vaccination charge was Kshs 100 per dog/cat. This resultant dog coverage was 2.8%. The charge was higher than 0.78 US Dollars or Kshs 62 (Kshs 80 per dollar in 2013) per dog/cat above which 70% dog coverage cannot be achieved (Dürr *et al.*, 2008). The county dog coverage was also significantly lower than the point estimate of 68% coverage achieved in 'free of charge' dog vaccination in Africa (Jibat *et al.*, 2015), showing that high cost of vaccination was likely to lower coverage in the county.

However, the performance of 2 sub-counties charging Kshs 50 was generally poorer than the 10 that charged Kshs 100 per dog/cat. This is unlikely to affect the reliability of the study as their proportion (16.7%) was quite low. The discrepancy could be attributed to diverse social factors which were not considered in this study.

5.3.1.5 Promotion of public awareness

Promotion of public awareness about all aspects of rabies is important in rabies endemic areas of the world. Where the such programmes are lacking, public awareness is usually low, negatively affecting vaccination coverage.

In general, the veterinary department had not taken steps to promote public awareness in rabies control. This agrees with Okonko *et al.*, (2010) observation that developing countries lack public health campaign programmes, negatively affecting rabies control and elimination. However, 4 (33.3%) sub-counties that promoted the awareness performed worse than those that did not. The discrepancy observed could have resulted from use of inappropriate promotion strategies that had little impact in rabies control.

5.3.1.6 'One Health' collaboration

Although the approach to zoonotic disease control was well known to the respondents, it was rated as fair, suggesting that there was little coordination and collaboration between veterinary and medical professionals. According to Lembo *et al.*, (2010), rabies control is well achieved through joint financing of control activities between veterinary and medical professions. In a previous study, Kagira *et al.*, (2012) found that 'One Health' collaboration in Kisumu City, Kenya was minimal and irregular and was likely to be a major constraint in rabies control.

5.3.2 Epidemiological factors

5.3.2.1 Cut off age for puppy vaccination

Rabies vaccines are licensed and approved for vaccination of dogs from 3 months of age. In the study, puppies less than 3 months of age were generally excluded from vaccinations. This concurs with previous studies where puppies younger than 3 months were not considered for vaccination (Lapiz *et al*., 2012; Jibat *et al*., 2015). Considering that puppies less than 3 months old comprise over 30% of African dog populations (Lembo *et al.*, 2010; Gsell *et al.*, 2012), the cut-off age negatively affects the coverage. The situation was worsened by the 5(41.7%) respondents that started vaccination of puppies at 4 and 6 months of age, delaying the vaccination further. This indicates ignorance on policy guidelines.

The cut-off age is unwarranted as research has shown that such puppies can be safely vaccinated without the interference of maternal derived antibodies. Further, those with no passive immunity develop protective antibody titers after vaccination as early as 4 weeks of age (Lembo *et al*., 2010). Further, the study shows that the respondents were likely to have been unaware of the research findings.

5.3.2.2 Dog trade factors

Dog trade is important in the epidemiology of rabies as it introduces of a large number of susceptible dogs between vaccination programmes. The study revealed that a large number of dogs (over 10,712 per year or 206 per week) of unknown vaccination status were moved into the county from neighboring counties. In a previous study, Kitala *et al.*, (2002) found that introduction of a large number of unimmunized dogs lowers coverage in dog populations. Dog trade in the county is likely to have negatively affected coverage.

5.3.3 Infrastructural factors

5.3.3.1 Availability of cold chain

Rabies vaccine is preserved at a temperature of 2^0C-8^0C. A long period of power interruption raises the refrigerator temperature to levels above 8^0C and could kill vaccines. Alternative power supply is, therefore, needed for use during power failures. Refrigerators were generally available in the county but alternative power supply was lacking. This indicates that maintaining cold chain during power disruptions was a common problem and could negatively affect the actual coverage when vaccines lose viability. No previous studies relate to these findings.

The use of deep freezers by some respondents during power disruptions may freeze and kill vaccines as temperature in deep freezer chambers are less than 2^0C. Likewise, doing nothing could also kill the vaccines when temperature rises above 8^0C, negatively affecting actual coverage.

5.3.3.2 Vaccine quality assurance

The quality of rabies vaccine needs to be guaranteed for effective and efficient vaccination programmes. In addition, it assesses how well the cold chain is maintained. In the study, vaccine was not tested for viability, indicating that vaccine efficacy was not guaranteed and could, therefore, lower actual coverage. No previous studies relate to these findings. In a previous study in Nigeria, Oladokun *et al.*, (2010) found that rabies vaccine that had been in the field for almost one year had lost its viability and potency probably due to poor handling. Therefore, vaccines should be tested regularly to guarantee efficacy.

5.3.4 Policy, strategy and legislative factors

5.3.4.1 Enforcement of rabies control laws

Kenya has adequate rabies control laws. However, enforcement of compulsory vaccination of dogs and control of dog movement laws were insufficient in the county, resulting in a large number of unvaccinated as well as roaming dogs. No previous studies relate to these findings.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Rabies is endemic in Kakamega County. Its incidence was quite low despite the fact that it was likely to have been underestimated. This means that the true burden and magnitude of the disease cannot be determined. The diagnosis of rabies was mainly passive, making it difficult to ascertain its true status.

Cat vaccination was neglected. Dog vaccination coverage was significantly lower than the recommended global 70% coverage necessary for rabies elimination. The low coverage could not control rabies and was responsible for rabies endemicity in the county. There was a significant difference in sub-county dog coverage.

Vaccination coverage was hampered by inadequate documentation of dog and cat population sizes, knowledge of coverage, resources, public awareness programmes, 'One Health' collaboration, cold chain and vaccine quality assurance infrastructure, high cost of vaccination, a 3-month cut off age in puppy vaccination, influx of dogs of unknown vaccination status and poor enforcement of rabies control laws.

6.2 RECOMMENDATIONS

The following recommendations are made to the Veterinary department:-

Sustainable rabies surveillance and incidence reporting through organized community approaches are needed. A standard reference rabies diagnosis laboratory should be constructed in the county to make diagnosis of rabies easy and reliable.

Regular, well planned and executed programmes for vaccination of dogs and cats through 'One health' approach to rabies elimination are needed. In addition, a continuous vaccination scheme for dogs and cats born or introduced between vaccination programmes should also be practiced. Regular public enlightenment programmes focusing on rabies and its control measures through use of pamphlets, posters, radio, television and print media announcements and other public forums are also needed. Adequate support by the county government and partnerships with the private sector, non-government organizations and other relevant donor agencies for the provision of necessary logistics and funding are also required..

Documentation of dog and cat population sizes necessary for effective planning of vaccination programmes, provision of 'free of charge' vaccination and change of rabies policy to include puppies less than 3 months old in vaccinations are required. Backup power generators for maintaining cold chain and vaccine quality assurance infrastructure are needed to ensure vaccine in use is potent. Strict and adequate enforcement of control of dog movement, mandatory vaccination and other rabies control laws is also required for effective elimination of the disease.

6.2.1 Recommendation for further research

Further research is required to assess social factors influencing the uptake of dog and cat vaccination.

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APPENDICES

Appendix 1 Consent to participate in the study

Investigator: Moses Njeru Mwangi, School of Public Health, Moi University.

Study title: Rabies incidence and vaccination coverage in dogs and cats in Kakamega County, Kenya.

Purpose and Background
The purpose of this study is to fill gaps in knowledge regarding rabies incidence and vaccination coverage in dogs and cats in Kakamega County, Kenya and the translation of the outcomes into recommendations for policy makers and other stakeholders involved in rabies control.

Procedure

Sub-County Veterinary officers in Kakamega County will be requested to provide information on rabies cases and vaccination figures in dogs and cats. They will also be interviewed on factors affecting rabies vaccination coverage in dogs and cats.

Benefits and Risks

There will be no direct benefit or risks for those participating in the study.

Confidentiality

All information given in this study will be confidential and will be used only for the purpose of the study.

Voluntary Participation

The participation in the study is entirely voluntary. Participants are, therefore, free to accept, refuse to take part in the study and may also withdraw at any time of the study.

Contact

1. The proposal has been reviewed by Institutional Research Ethics Committee (IREC) of Moi Teaching and Referral Hospital (MTRH) and Moi University. The committee ensures the research participants are protected from harm. If you wish to find more from the committee, you may contact:

   The Administrator,
   IREC,
   P.O. Box 4606-30100,
   ELDORET
   Tel. 33471/2/3

2. You may also address your questions or any issues requiring clarification now or at any time of the study to the investigator through the following contact:

   Moses Njeru Mwangi,
   School of public Health,
   Moi University,
   P.O. Box 4606-30100,
   ELDORET
   TEL. 0727398235
   Email: moses.njeru@yahoo.com

Consent

I have understood the nature of the study and voluntarily agree to participate in the study.

Signature of participant …………………………………..

Date ………………………………………..

Signature of researcher ……………………………

Date ……………………………………………….

Appendix 2 Questionnaire for Sub-County Veterinary officers

Serial Number …….......

Sub-County …………………………………..

Instructions

a) Please do not write your name or that of your area of work on the questionnaire.

b) Please answer the questions by ticking on the appropriate box and by filling the spaces provided.

Section A: Operational related factors

Q1. How do you plan for dog and cat rabies vaccination?

a) By using past vaccination records 1) Yes ☐ 2) No ☐

b) Through estimation of their populations 1) Yes ☐ No ☐

c) Other (Specify)…………………………………………………………………

Q2. Do you get adequate resources for use in dog and cat rabies vaccination?

1) Yes ☐ 2) No ☐

Q3. If no to Q2, which resources limit the coverage in rabies vaccination programmes? You may choose more than one answer.

1) Funds ☐ 2) Transport ☐ 3) Technical personnel ☐

4) Equipment ☐ 5) Subsidized rabies vaccine ☐

Other (Specify)…………………………………………………………………………

Q4. What is the source of your rabies vaccine? You may tick more than one answer.

1) Government supplies ☐ 2) Drug outlets ☐

2) Pharmaceutical companies ☐ 3) Donors agencies ☐

Other (Specify)……………………………………………………………………………

Q5. Is rabies vaccine always available in your office? Yes ☐ No ☐

Q6. Do you charge for vaccinating:-

a) Dogs/cats? 1) Yes ☐ 2) No ☐

b) Livestock? 1) Yes ☐ 2) No ☐

Q7. If yes to Q6, how much do you charge for vaccinating dogs and cats?

a) In annual vaccination campaign programmes Kshs ……………..

b) Outside annual vaccination campaign programmes Kshs ……………..

Q8. Do you hold joint vaccination campaigns for dogs, cats and livestock?

1) Yes ☐ 2) No ☐

Q9. How do you rate the availability of dogs and cats in rabies vaccination campaigns?

a) Dogs: 1) Excellent ☐ 2) Very good ☐ 3) Good ☐
4) Fair ☐ 5) Poor ☐ 6) Negligible ☐

b) Cats: 1) Excellent ☐ 2) Very good ☐ 3) Good ☐
4) Fair ☐ 5) Poor ☐ 6) Negligible ☐

Q10. Are public awareness campaigns for rabies control held in your area?

1) Yes ☐ 2) No ☐

Q11. If yes to Q10, how often are they held?

1) Monthly ☐ 2) Quarterly (four times a year) ☐

3) Biannually ☐ 4) Annually ☐

Other (Specify)…………………………………………………………………………

Q12. If yes to Q10, which media do you use? You may tick more than one answer.

1) Print media (Newspapers) ☐ 2) Radio/Television ☐

3) Public barazas ☐ 4) Workshops ☐ 5) Field days ☐

Other (Specify) ……………………………………………………………………………..

Q13. If no to Q10, please give reasons………………………………………………………..

……..

……………………………………………………………………………………………

Q14. Do you maintain a record of dog and cat rabies vaccination?

1) Yes ☐ 2) No ☐

Q15. Do you always get monthly vaccination reports from veterinary private practitioners?

1) Yes ☐ 2) No ☐

Q16. Have you heard of 'One Health' approach in solving human and animal health problems?

1) Yes ☐ No ☐

Q17. If yes to Q16, what is the source of the information? You may tick more than one answer.

1) Print Media (Newspapers) ☐ 2) Television/Radios ☐

3) Professional friends ☐ 4) Seminars ☐ 5) Conferences ☐

Other (Specify) ………………………………………………………………

Q18. If yes to Q16, how do you rate 'One Health' in the implementation of dog and cat rabies vaccination campaigns in your area of work?

1) Excellent ☐ 2) Very good ☐ 3) Good ☐ 4) Fair ☐ 5) Poor ☐

Section B: Epidemiological related factors

Q19. At what age do you start vaccinating dogs against rabies? ....

Q20. Do you have a dog market or markets in your area of work?

1) Yes ☐ 2) No ☐

If no to Q20, please skip Q21 to Q26.

Q21. What is the average number of dogs sold in the market per week? Please fill the table below.

S/No	**Market Name**	**Average number of dogs sold per week**
1.		
2.		

Q22. What are the counties of origin of the dogs sold in your market? …………….........

………………………………………………………………………………………………

Q23. What proportion of dogs presented in the market is accompanied by rabies vaccination certificates? ………………

Q24. Are dogs vaccinated against rabies in your market?

1) Yes ☐ 2) No ☐

Q25. If yes to Q24, approximately what proportion is vaccinated in a market day? ....

Q26. What are the counties of destination of the dogs sold in your market? ....

………………………………………………………………………………………………

Section C: Infrastructural related factors

Q27. Is cold chain available in your office? 1) Yes ☐ 2) No ☐

Q28. If no to 27, where do you preserve vaccines? Tick one.

1) Personal cold chain ☐ 2) Borrowed cold chain ☐

Other (Specify)……………………………………………………………………………

Q29. If yes to Q27, do you have an alternative power supply to use during interruptions?

1) Yes ☐ 2) No ☐

Q30. If no to Q29, how do you preserve vaccine during power failures?

………………………………………………………………………………………………

………………………………………………………………………………………………

Q31. Are your rabies vaccines tested for viability?

1) Yes ☐ 2) No ☐

Q32. If yes to Q31, how often are the tests carried out in a year? ………………………….

Q33. If yes to Q31, have you ever had results indicating vaccines are not viable?

1) Yes ☐ No ☐

Q34. If no to Q31, please give reasons…………………………………………………..

………………………………………………………………………………………………

………………………………………………………………………………………………

Section D: Policy, strategy and legislative related factors

Q35. Are dog rabies vaccination defaulters prosecuted in your area of work?

1) Yes ☐ 2) No ☐

Q36. If yes to Q35, approximately how many defaulters are prosecuted annually?.............

Q37. Are dog owners prosecuted for failing to confine dogs?

1) Yes ☐ 2) No ☐

Q38. If yes to Q37, approximately how many dog owners are prosecuted annually?..........

Q39. Is the movement of dogs into your area authorized?

1) Always ☐ 2) Sometimes ☐ 3) Not at all ☐ 4) I do not know ☐

Q40. Do you authorize the movement of dogs within and out of your area?

1) Always ☐ 2) Sometimes ☐ 3) Not at all ☐

Q41. What is the urgency of rabies elimination in Kenya?

1) Most urgent ☐ 2) Urgent ☐ 3) Not urgent ☐

Q42. Please support your answer in Q41
…………………………………………………...

…………………………………………………………………………………………….
.

……………………………………………………………………………………………

……………………………………………………………………………………………

Q43. Why is dog trade on the increase in Kakamega County unlike other rabies control areas in Kenya?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Section E. Other associated factors

Q44. What other factors affect dog and cat rabies vaccination coverage in your area?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

End of the questionnaire. Thank you very much for your participation.

Appendix 3: Additional tables

Table 4.4: Sub-county pairwise comparisons

Sub-counties	N	Sum of ranks	Mean rank	Mann-Whitney U	p-value
Lugari Khwisero	5 5	26.00 29.00	5.20 5.80	11.000	0.753
Lugari Ikolomani	5 5	20.00 35.00	4.00 7.00	5.000	0.112
Lugari Matungu	5 5	34.00 21.00	6.80 4.20	6.000	0.172
Lugari Butere	5 5	28.00 27.00	5.60 5.40	12.000	0.916
Lugari Mumias	5 5	25.50 29.50	5.10 5.90	10.500	0.674
Lugari Matete	5 5	15.00 40.00	3.00 8.00	0.000	0.009
Lugari Lurambi	5 5	17.00 38.00	3.40 7.60	2.000	0.028
Lugari Shinyalu	5 5	27.00 28.00	5.40 5.60	12.000	0.917
Lugari Malava	5 4	23.00 22.00	4.60 5.50	8.000	0.621
Lugari Navakholo	5 5	35.00 20.00	7.00 4.00	5.000	0.112
Lugari Likuyani	5 5	20.00 35.00	4.00 7.00	5.000	0.116
Khwisero Ikolomani	5 5	15.00 40.00	3.00 8.00	0.000	0.008
Khwisero Matungu	5 5	40.00 15.00	8.00 3.00	0.000	0.009
Khwisero Butere	5 5	30.00 25.00	6.00 5.00	10.000	0.599
Khwisero Mumias	5 5	27.00 28.00	5.40 5.60	12.000	0.915
Khwisero Matete	5 5	15.00 40.00	3.00 8.00	0.000	0.009
Khwisero Lurambi	5 5	16.00 39.00	3.20 7.80	1.000	0.016

Khwisero Shinyalu	5 5	30.00 25.00	6.00 5.00	10.000	0.600
Khwisero Malava	5 4	25.00 20.00	5.00 5.00	10.000	1.000
Khwisero Navakholo	5 5	40.00 15.00	8.00 3.00	0.000	0.008
Khwisero Likuyani	5 5	20.00 34.00	4.10 6.90	5.500	0.141
Ikolomani Matungu	5 5	40.00 15.00	8.00 3.00	0.000	0.009
Ikolomani Butere	5 5	35.00 20.00	7.00 4.00	5.000	0.112
Ikolomani Mumias	5 5	35.00 20.00	7.00 4.00	5.000	0.113
Ikolomani Matete	5 5	15.00 40.00	3.00 8.00	0.000	0.008
Ikolomani Lurambi	5 5	25.00 30.00	5.00 6.00	10.000	0.597
Ikolomani Shinyalu	5 5	30.00 25.00	6.00 5.00	10.000	0.597
Ikolomani Malava	5 4	25.00 20.00	5.00 5.00	10.000	1.000
Ikolomani Navakholo	5 5	40.00 15.00	8.00 3.00	0.000	0.007
Ikolomani Likuyani	5 5	25.00 30.00	5.00 6.00	10.000	0.597
Matungu Butere	5 5	30.00 25.00	6.00 5.00	10.000	0.599
Matungu Mumias	5 5	15.00 40.00	3.00 8.00	0.000	0.009
Matungu Matete	5 5	15.00 40.00	3.00 8.00	0.000	0.009
Matungu Lurambi	5 5	15.00 40.00	3.00 8.00	0.000	0.009
Matungu Shinyalu	5 5	25.00 30.00	5.00 6.00	0.000	0.597
Matungu Malava	5 4	25.00 20.00	5.00 5.00	10.000	1.000
Matungu Navakholo	5 5	25.00 30.00	5.00 6.00	10.000	0.596

Matungu Likuyani	5 5	20.00 35.00	4.00 7.00	5.000	0.116
Butere Mumias	5 5	24.00 31.00	4.80 6.20	9.000	0.463
Butere Matete	5 5	15.00 40.00	3.00 8.00	0.000	0.009
Butere Lurambi	5 5	19.00 36.00	3.80 7.20	4.000	0.075
Butere Shinyalu	5 5	21.00 34.00	4.20 6.80	6.000	0.173
Butere Malava	5 4	20.00 25.00	4.00 6.25	5.000	0.211
Butere Navakholo	5 5	25.00 30.00	5.00 6.00	10.000	0.596
Butere Likuyani	5 5	22.00 33.00	4.40 6.60	7.000	0.245
Mumias Matete	5 5	15.00 40.00	3.00 8.00	0.000	0.009
Mumias Lurambi	5 5	18.00 37.00	3.60 7.40	3.000	0.047
Mumias Shinyalu	5 5	30.00 25.00	6.00 5.00	10.000	0.602
Mumias Malava	5 4	25.00 20.00	5.00 4.00	10.000	1.000
Mumias Navakholo	5 5	40.00 15.00	8.00 3.00	0.000	0.008
Mumias Likuyani	5 5	21.50 33.50	4.30 6.70	6.500	0.209
Matete Lurambi	5 5	38.00 17.00	7.60 3.40	2.000	0.028
Matete Shinyalu	5 5	40.00 15.00	8.00 3.00	0.000	0.009
Matete Malava	5 4	35.00 10.00	7.00 2.50	0.000	0.014
Matete Navakholo	5 5	40 15	8.00 3.00	0.000	0.008
Matete Likuyani	5 5	39.00 16.00	7.80 3.20	1.000	0.016
Lurambi Shinyalu	5 5	36.00 19.00	7.20 3.80	4.000	0.076

Lurambi Malava	5 4	30.50 14.50	6.10 3.62	4.500	0.174
Lurambi Navakholo	5 5	40.00 15.00	8.00 3.00	0.000	0.008
Lurambi Likuyani	5 5	41.50 23.50	6.30 4.70	8.500	0.402
Shinyalu Malava	5 4	26.50 18.50	5.30 4.62	8.500	0.711
Shinyalu Navakholo	5 5	25.00 30.00	5.00 6.00	10.000	0.597
Shinyalu Likuyani	5 5	26.00 29.00	5.20 5.80	11.000	0.754
Malava Navakholo	4 5	20.00 25.00	5.00 5.00	10.000	1.000
Malava Likuyani	5 5	20.00 25.00	5.00 5.00	10.000	1.000
Navakholo Likuyani	5 5	20.00 25.00	4.00 7.00	5.000	0.113

Appendix 4 Formal study approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET

Reference: IREC/2014/87
Approval Number: 0001230

31st July, 2014

Mr. Moses N.Mwangi,
Moi University,
School of Public Health,
P.O.Box 4606-30100
ELDORET-KENYA.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
31 JUL 2014
APPROVED
P. O. Box 4606-30100 ELDORET

Dear Mr. Mwangi,

RE: FORMAL APPROVAL

The Institutional Research and Ethics Committee has reviewed your research proposal titled:-

"Rabies Prevalence and Vaccination Coverage in Dogs and Cats in Kakamega County, Kenya".

Your proposal has been granted a Formal Approval Number: ***FAN: IREC 1230 on*** 31st July, 2014. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 30th July, 2015. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	Director	-	MTRH	Dean	-	SOP	Dean	-	SOM
	Principal	-	CHS	Dean	-	SON	Dean	-	SOD

Appendix 5 Permission to conduct a research study

REPUBLIC OF KENYA

MINISTRY OF AGRICULTURE,LIVESTOCK COOPERATIVES & FISHERIES RESOURCES

DEPARTMENT OF VETERINARY SERVICES.

Telegrams "MIFUGO" Kakamega
Telephone: 056-31377/31291
When replying please Quote

County Director of Veterinary Services
Kakamega County
P.O. Box 871 - 50100
KAKAMEGA

Ref No. CGK/VET/2/3/4

Date: 20th August, 2014.

Dr. Moses Njeru Mwangi.
P.O.BOX 424-30205
MATUNDA.

REF: PERMISSION TO CONDUCT A RESEARCH STUDY.

Please refer to your letter dated 19th August 2014 on the above subject.
Your request has been considered and accepted. Permission is therefore granted to you to commence the study in Kakamega County.
This office assures you maximum cooperation in the period of your study.

Dr. F. J. Mulala
County Director of Veterinary Services
KAKAMEGA

County Director of Veterinary Services
KAKAMEGA COUNTY
P. O. Box 871-50100 KAKAMEGA
Date..................Sign..................

Director of veterinary services
Central veterinary laboratories.
P.O. Private Bag
00625 – KANGEMI
NAIROBI

Human Resource Manager
Kakamega County
P.O.BOX 36 – 50100
KAKAMEGA.