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**KNOWLEDGE, ATTITUDE, AND PRACTICES REGARDING FOOT AND
MOUTH DISEASE VACCINATION AMONG CATTLE FARMERS IN
MUKONO CENTRAL DIVISION, MUKONO DISTRICT.**

BY

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DECLARATION AND APPROVAL

I **David Katumba**, hereby declare that this research study report is a product of my own efforts and to the best of my knowledge, has not been presented to any university for any award.

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DEDICATION

This research is dedicated to my mother Prossy Nakachwa, my sister Faith Nagwa and my brother Denis Ssegawa who have always believed in me and encouraged me to go on in every difficult situation.

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ABSTRACT

This study aimed to assess the knowledge, attitudes, and practices of cattle farmers regarding FMD vaccination in Mukono Central Division, Mukono District. A cross-sectional study was conducted involving 158 cattle farmers using a structured questionnaire administered face to face covering, sociodemographic characteristics, knowledge of FMD transmission and clinical signs, attitudes towards vaccination, vaccination practices, and barriers to vaccination uptake. All respondents (100%) had heard of FMD and FMD vaccination, The most commonly recognised clinical signs were blisters in the mouth (62.7%), hypersalivation (59.5%). Direct contact with infected animals was the most frequently recognised transmission route. Regarding other susceptible species, most of the farmers knew goats while one quarter did not know other affected species. Only 64 farmers (40.5%) reported that their cattle had been vaccinated, whereas 94 (59.5%) had not. The main reported concerns were vaccination cost and effectiveness. More than half of farmers reported that vaccination services were difficult or very difficult to access, and 66.5% had never received formal training on FMD vaccination or control. All farmers reported that vaccination was conducted only during outbreaks. Vaccination status was significantly associated with farming experience, age, number of cattle owned, knowledge of other susceptible species, perceived vaccine effectiveness, reported vaccination concerns, affordability, accessibility, and response time following disease reporting. The study revealed that while cattle farmers in Mukono Central Division have good general awareness and positive attitudes toward FMD vaccination, actual practice remains low and important gaps in detailed disease knowledge. Vaccination practices were largely outbreak-oriented, while cost, limited access to vaccination services, inadequate training, and concerns about vaccine effectiveness presented important barriers. Addressing these factors through routine farmer education using local languages, practical demonstrations, community-based vaccination campaigns subsidizing or farmer-group cost-sharing, and appropriate vaccination schedules. may improve routine vaccination uptake and strengthen sustainable FMD control in Mukono Central Division and similar cattle-producing areas of Uganda.

Keywords: Foot-and-mouth disease; vaccination; cattle farmers; knowledge; attitudes; practices; vaccination uptake; barriers; Mukono Central Division; Uganda.

CHAPTER ONE

INTRODUCTION

1.1 Background

In Uganda, livestock rearing is an integral component of rural livelihoods and a key contributor to agricultural GDP, which accounts for about 24% of GDP, with livestock farming supporting over 70% of rural households, and contributing roughly 5-10% (UBOS, 2020). Livestock products including meat, milk, eggs, and hides serve as essential sources of nutrition and income for millions. Beyond direct benefits, livestock also accumulates wealth and serve as collateral in rural economies (Mpuga, 2016).

Despite its importance, livestock production is constrained by outbreaks of diseases such as Foot-and-Mouth Disease (FMD), which cause substantial losses. Vaccination programs have been implemented to mitigate these challenges, but coverage and adoption rates vary widely across regions and socio-economic groups.

Foot-and-Mouth Disease (FMD) is a highly contagious viral disease affecting cloven-hoofed animals, including cattle, and poses significant threats to livestock productivity worldwide. FMD is a big threat to rural livelihoods and economic development, with annual outbreaks ranging from 17 to 37 incidents (Mwiine *et al.*, 2019; Munsey *et al.*, 2019). The trade restrictions affected farmers experiencing up to 55% drops in cattle prices during outbreaks (Ayebazibwe *et al.*, 2010; Baluka, 2016).

Mukono District, located in central Uganda, is a key cattle-producing area with an estimated number of 800,000 to 1,000,000 heads. (UBOS, 2024; NLC 2021 Abridged Report), with mixed farming systems, including smallholder and semi-commercial operations in its Central and Goma division. These divisions are characterized by high livestock densities and proximity to urban markets like Kampala, increasing the risk of disease transmission through animal movements. Historical outbreaks of FMD in Mukono, such as those reported in 2008 (the first in 20 years) and 2015, underscore the vulnerability of local herds (Mwiine *et al.*, 2019). Vaccination is a primary control strategy for FMD, yet coverage in Uganda remains low, often below 50% in affected districts, due to factors like cost, availability of the vaccine, and irregular campaigns (Balinda *et al.*, 2009; WRLFMD, 2025). Understanding cattle farmers' knowledge, attitudes, and

practices (KAP) towards FMD vaccination is crucial for designing effective interventions to enhance disease control and improve livestock health in these areas.

Additionally, cattle farmers' knowledge gaps and negative attitudes toward vaccination, often driven by misinformation, and inadequate access to veterinary services have been reported to vaccine adoption (Nakkazi, 2022). For example, only 55% of small-scale livestock keepers were able to correctly identify benefits of vaccination in a recent study in Eastern Uganda (Ochieng *et al.*, 2024).

The aim of the study was to assess the knowledge, attitudes, and practices of cattle farmers regarding FMD vaccination in Mukono central division. Foot and mouth disease is a highly contagious disease with the potential to cause severe economic loss in susceptible cloven-hoofed animals especially cattle. Collecting information relating to knowledge, attitudes and practices (KAPs) of farmers is a significant step towards the control and eradication of FMD. In low-income countries, such as Uganda, livestock, especially cattle, are very important and minimizing the impact of disease on these animals is critical for maintaining the livelihood of the rural communities. It is important in that when developing and implementing disease control and prevention strategies, to ensure that the public, especially the farming community, is aware of the disease, communication between the veterinary authorities and farmers is essential for a successful preventive and control strategy in this area, not only relying on a high adoption level of vaccination, but also on effective responses to outbreaks, restricting and monitoring the movement of susceptible animals within Mukono Central Division.

1.2 Problem Statement

Despite government efforts, including cost-shared vaccination programs, FMD persists in Uganda. In Mukono Central Division, where cattle farming is integral to the livelihoods, low vaccination uptake contributes to recurrent outbreaks exacerbating economic hardships for smallholder farmers (Baluka, 2016). This leaves a detailed knowledge gap on FMD and FMD vaccination such as transmission, other species affected, farmers attitudes influencing vaccination compliance, and gaps in practical measures in control and prevention of FMD which hinder targeted extension services and policy formulation, leading to continued disease spread and losses through animal death, reduced production of milk and meat as well as drop in market price per animal annually without control measures. To my knowledge, there have been no studies on the KAP concerning of FMD

and its vaccination in Mukono Central Division or other parts of Uganda and addressing cattle farmers' KAP is essential to bridge this gap and promote sustainable FMD management

1.3 Research objectives

1.3.1 General Objective

The general objective of the study is to; assess the knowledge, attitudes, and practices of cattle farmers regarding FMD vaccination program in Mukono central division.

1.3.2 Specific Objectives

- i. Determine the level of knowledge among cattle farmers in Mukono central division on FMD transmission, clinical signs, and the role of vaccination
- ii. Evaluate cattle farmers' attitudes in Mukono central division towards FMD vaccination
- iii. Identify current practices related to FMD prevention and control, with a focus on vaccination adoption and barriers.

1.4 Research Question

The study will reason the following research objectives;

1. What is the status of cattle farmers' knowledge regarding FMD transmission, clinical signs, and the role of vaccination?
2. How do cattle farmers' attitudes influence their willingness to vaccinate cattle against FMD?
3. What are the prevailing practices among cattle farmers in preventing and control FMD, vaccination adoption and barriers?

Hypothesis: if the knowledge, attitude and practices of cattle farmers regarding FMD vaccination is known, there will be increased vaccination uptake.

1.5 Justification

Identifying gaps in cattle farmers' knowledge, attitudes, and practices regarding livestock vaccination against FMD is crucial. Understanding these gaps will guide the creation of customized education, outreach, and veterinary service interventions. Such measures will

increase vaccination rates, lower livestock deaths, improve rural livelihoods, and contribute to Uganda's sustainable livestock disease control efforts in line with national agricultural goals and the Global Action Plan on antimicrobial resistance.

1.6 Significance

This study will provide baseline data of knowledge and awareness of FMD among cattle farmers, their attitudes towards FMD vaccination as a major prevention and control of FMD strategy for Uganda, prevailing practices farmers are doing to control spread of the FMD and the barriers that hinder them from vaccinating their cattle against FMD. These findings may guide policy making on vaccine subsidies and awareness campaigns to increase vaccination uptake, potentially replicable in other districts and could enhance farmer incomes, food security. Ultimately, an improved KAP could yield a benefit-cost ratio of 1.41 for FMD control, that is to say; that for every unit of cost invested in controlling FMD, the estimated benefits such as improved food security, increased farmer incomes, and reduced zoonotic risks are 1.41 times greater. A benefit cost ratio greater than 1 indicates that the benefits outweigh the costs, suggesting that the intervention is economically advantageous based on prior analyses in Uganda (Baluka, 2016; UBOS, 2024).

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter synthesizes existing literature to Foot-and-Mouth Disease (FMD), aetiology and serotypes, epidemiology, risk factors, transmission, incubation period, pathogenesis, clinical signs, laboratory diagnosis, and control of FMD. It also describes the progressive control pathway and the FMD control protocol in Uganda, factors influencing cattle farmer's behaviour on FMD, FMD vaccination and the different biosecurity interventions or practices against FMD.

2.1 Overview of Foot-and-Mouth Disease (FMD)

Foot-and-Mouth Disease is a severe, highly contagious viral infection affecting cloven-hoofed domestic and wild animals of the order *Artiodactyla*, including livestock hosts like cattle, sheep, goats, pigs and many wild artiodactyls, including African buffalo, bison, giraffes, Bactrian camels, deer, and antelope. Asian elephants (order *Proboscidea*) are also susceptible. Due to its highly contagious nature and economic importance for many countries, FMD is the first disease for which the Office International des Epizooties (OIE) established an official list of free countries and zones (Ismael *et al.*, 2009). It is on list A of the notifiable disease of the world organization for animal health (OIE) and is also regarded as a transboundary animal disease (TAD) that deeply affects the production of livestock and disrupts regional and international trade in animals and animal products. It is not considered a public health problem (Cox, 2001). The first FMD outbreak in Uganda was recorded in 1953 and since then many outbreaks involving all FMD viral Sero-types except for Asia 1 have been reported in the country (Muleme *et al.*, 2013). However, the earliest description of the probable foot and mouth disease in cattle was made by an Italian monk, Hieronymus Fracastorius in Venice in 1514 (Jamal & Belsham, 2013)

2.2 Aetiology and Serotypes of FMD

The disease is caused by an *Aphthovirus* of the family *Picornaviridae*. The virus is a single-stranded positive sense RNA virus. There are seven viral serotypes A, O, C, Southern African Territories (SAT) SAT1, SAT2, SAT3, and Asia 1 (Rout & Sanyal, 2012). FMDV serotype C has not been isolated by the network of WOA/FAO Reference Laboratories for FMD since 2004, and no serotype C events have been reported to WOA/

since then (OIE, 2026). Further diversity is found between strains within each serotype. Serotypes O and A were initially discovered by Vallee and Carre in 1922. They name these serotypes after their place of origin: O for the department of Osie in France and A for the Allemagne (French word for Germany). In 1926, Waldmann and Trautwein discovered the third serotype which was named serotype C. In 1940s, three other serotypes were then identified in samples originating from south Africa and they were named Southern African Territories 1,2,3 (SAT1, SAT2, SAT3). The seventh serotype, Asia 1 was initially detected in a sample from a water buffalo at Okara, Punjab, Pakistan in 1954 (Jamal & Belsham, 2013).

2.3 Epidemiology of Foot and Mouth Disease

FMD is distributed worldwide but has been eradicated from North and Central America, most of South America, Europe, and Australia. It has not been reported in New Zealand and Antarctica. In a susceptible population, morbidity can reach 100%; however, fatalities are rare except in young animals or when lesions become secondarily infected by bacteria with mortality ranging from 20% to 25% (Depa *et al.*, 2012). The disease can be easily reintroduced into FMD-free areas unless strict precautions are in place. Outbreaks in FMD-free areas can be severely disruptive and require substantial resources to control, as in the 2001 epizootic in the UK. This outbreak, which lasted for approximately 8 months, is estimated to have cost approximately \$10 billion (USD). Major components of the cost of outbreaks in free areas include lost trade and the large numbers of animals culled to limit spread of the disease (NAO Report, 2002).

The different serotypes of FMD virus are not uniformly distributed within the endemic regions. Serotype O is responsible for the majority of outbreaks globally. Six of the 7 serotypes have occurred in Africa (O, A, C, SAT1, SAT2, SAT3) the circulation of these serotypes vary in each region; East Africa (O, A, C, SAT1, SAT2, SAT3), centra Africa (O, A, SAT1, SAT2) west Africa (SAT2, O, A, SAT1), North Africa (A, O, SAT2). In southern Africa, SAT1, SAT2, and SAT3 serotypes of FMDV are maintained by large numbers of African buffaloes (*Syncerus caffer*) which provide a potential source of infection to domestic and wild animals (Banda *et al.*, 2014). In Asia (O, A, C, Asia 1, SAT 1, and SAT 2), and 3 in South America (O, A, C). Most of the Americas, Australia, New Zealand, and Europe are now normally free of FMD (the last outbreaks in Europe were in Germany, Hungary, Slovakia, and Cyprus in 2025) (Guillaume *et al.*, 2025).

In Uganda, where FMD is endemic, with the first outbreak in 1953 and responsible serotype is O, subsequent outbreaks have followed with other serotypes A, SAT1, and SAT2 identified in cattle. SAT1, SAT2, and SAT3 have also been reported in Uganda African buffalo (*Syncerus caffer*) (Namatovu *et al.*, 2015). It has been reported that FMD clinical case have been increasing in Uganda from 2000's as compared to 1990's (Velazquez-Salinas *et al.*, 2020).

2.4 Prevalence of Foot and mouth disease

There are no reliable figures for the prevalence of FMD in different countries. The disease generally occurs in the form of an outbreak that rapidly spreads from herd to herd before it is controlled. Of the 7 standard serotypes, O, A and C are the prevalent in all continents where the disease occurs, SAT 1 is found in Africa and Asia, SAT2 and SAT3 are limited to Africa, whereas Asia 1 occurs only in Asia. These limitations are due to more to the pattern of the meat trade than to any inherent properties of the serotypes. Overall, serotypes O and A occur more frequently than others. (Radostits, 2000).

2.5 Risk Factors

2.5.1 Host Factors

The disease has a wide host range but it is most important in cattle and pigs. Goats and sheep are also affected exhibit mild or asymptomatic signs of the disease (Kitching & Hughes, 2002; Thornley&France,2009). However, cattle, sheep and goats can all be carriers, they are not regular sources of infection of FMDV. Young animals and those in good condition are relative susceptible and hereditary differences in susceptibility have also been observed. Horses are not susceptible to disease. A variety of wildlife species such as the deer in England, the water buffalo (*Bubalus bubalis*) in Brazil and wild ungulates in Africa become infected periodically but are believed to play little or no role as reservoirs of infection for domestic animals (Radostits, 2006).

A key exception is an African buffalo (*Syncerus caffer*), probably the natural host of the SAT serotypes of the virus and the major source of infection for cattle in southern Africa. The domesticated Asian buffalo also shows typical clinical disease and spreads from buffalo to other species. Small rodents and hedgehogs in Europe and capybaras in South America may also act as reservoirs (Radostits, 2006).

2.5.2 Environmental and Pathogen Factors.

FMD virus is environmentally resistant but can be easily inactivated outside the pH range 6–9, by desiccation, and at temperatures $> 56^{\circ}\text{C}$ (133°F). It is resistant to lipid solvents such as ether and chloroform; however, sodium hydroxide (lye), sodium carbonate (soda ash), citric acid, and acetic acid (vinegar) are effective disinfectants. Iodophors, quaternary ammonium compounds, hypochlorite, and phenols are less effective, especially in the presence of organic matter. FMD virus can survive on hay or straw bedding for up to 20 weeks, in dry faecal matter for up to 14 days in summer, in faecal slurry for up to 6 months in winter, and in soil for 3 (summer) to 28 (winter) days. However, the extent of virus survival in these materials is dependent on the initial level of contamination. In humans, the virus can persist in human nasal passages for up to 36 hours (Rout & Sanyal, 2012). FMD virus is shed into the milk of dairy cows before clinical signs develop. Infectivity is substantially decreased by heat treatment of milk; however, trace amounts of FMDV could survive, depending on the method. All uncooked meat tissues, including bone are likely to remain infective for long periods, especially if quick-frozen and to a lesser extent meat chilled or frozen by a slow process. The development of the acidity in rigor mortis inactivates the virus but quick freezing suspends formation and the virus is likely to survive.

2.5.3 Immune Mechanism

In endemic areas, periodic outbreaks occur which sweep through the animal populations and then subside. Immunity after natural infection lasts for 1-4 years in cattle and for a shorter time in pigs. The presence of more than one strain of the virus should be suspected when outbreaks follow each other rapidly. In countries where general vaccination is practiced every year, outbreaks are usually associated with different strains imported or infected meat (Radostits, 2006).

2.6 Transmission of FMDV

FMD virus is transmitted via various routes; direct contact with infected animals, indirect contact with secretions or excretions (including semen and milk) from infected animals, (Donaldson AI, 1997) mechanical vectors (people, horses, dogs and cats, rodents, birds, vehicles, and equipment), air movement over land and water. The virus can enter the host via inhalation, ingestion, or skin wounds and mucous membranes. (Alexanderson *et*

al.,2003). Breeding through abrasions or cuts is a possible route of transmission for the SAT viruses in African buffalo populations.

A potential scenario for introduction of the virus into a previously FMD-free area is for a susceptible population, such as pigs, to be given imported food derived from an infected animal. Virus then spreads from pigs, which can exhale a thousandfold more virus than cattle, to more susceptible cattle hosts via aerosol (Daves, 2002). FMD has high agroterrorism potential because of its infectivity, stability in the environment, and potential to cause enormous economic losses and societal disruption.

Humans can act as mechanical vectors of FMD by carrying virus on clothing or skin, respiratory tract, footwear. FMD is not a zoonosis and is not considered a public health problem. Individuals in contact with infected animals can have sufficient FMDV in their respiratory tract for 24 hours to serve as a source of infection for susceptible animals. The virus can persist in the human nasal passages for up to 36 hours, manure for 1 to 24 weeks, fodder for 1 month, and on shoes for 9 to 14 weeks (Rout & Sanyal, 2012).

2.7 Zoonotic implications

Humans are slightly susceptible to infection with the virus and vesicles may develop in the mouth or hands. Very few cases have been reported even among the people working with the virus in the laboratories or infected cases. However, humans can be vehicle for transmission to animals.

2.8 Incubation Period of FMD

The incubation period of FMD is variable and depends on the host, environment, route of exposure, and virus strain. After infection with FMD virus, the typical incubation period in sheep and goats is 3–8 days, 2 days and more in pigs, and 2–14 days in cattle Bactrian camels and, 2-3 days in elk, and almost up to 21 days in water buffalos infected by direct contact (Davies, 2002). The incubation period can be as short as 18 hours for host-adapted strains in pigs, especially under intense direct contact.

2.9 Pathogenesis of FMD

The primary sites of infection and replication of foot-and-mouth disease virus are the mucosa of the nasopharynx in cattle and the crypt epithelium of the oropharyngeal tonsils in pigs. The virus can also enter through skin lesions.

Once inside the body of an animal, the virus is distributed by the lymphatic system and blood, the virus replicates in the epithelium of the mouth, muzzle or snout, teats, feet, and areas of damaged skin (elbows and hocks of pigs). Vesicles develop quickly and rupture within 24-48 hours after exposure (Alexandersen *et al.*, 2003; Kitching, 2002).

More than 50% of ruminants that recover from FMD (including those that were vaccinated and later exposed to the virus) can become carriers i.e., they maintain low levels of infectious virus in their pharyngeal region long after the acute phase of infection. The carrier state can last for a few years in cattle, several months in sheep, and > 5 years in African buffalo. Strikingly, such persistent infections do not occur in pigs (Kitching, 2002). Animals can transmit the virus before the appearance of clinical signs because the virus replicates in the pharynx or mouth before disease or even viremia is observed (Sutmoller & Casas Olascoaga, 2002).

2.10 Clinical Signs of FMD in cattle

Clinical signs of foot-and-mouth disease in cattle include fever of approximately 40°C (104°F), followed by vesicular lesions appearing on the tongue, hard palate, dental pad, lips, gums, muzzle, coronary band, interdigital cleft, and teats in lactating animals. Acutely affected individuals can salivate profusely and make characteristic smacking noises, stamp their feet, and prefer to lie down. Ruptured oral vesicles can coalesce and form erosions but heal rapidly less than two weeks after vesicle formation. Vesicles on the feet of animals with FMD take longer to heal and are susceptible to secondary bacterial infection leading to chronic lameness or, in severe cases, death. Lesions can involve one or more feet (Alexandersen *et al.*, 2003) Secondary bacterial mastitis is common due to infected teat vesicles resulting in resistance to milking. After vesicular disease develops, cattle quickly lose condition and milk production diminishes, which can persist chronically.

Occasionally, young calves can die without prior clinical signs of illness because of virus-induced damage to the developing myocardium

Pigs infected with FMD virus show mild to severe lameness and blanching around the coronary bands and can develop a fever of up to 41.5°C (107°F). Affected pigs become lethargic, huddle among other pigs, and may have little interest in feed. Vesicles develop on the coronary band and the heel of the foot (including accessory digits), the snout, mandible, and tongue. Additional vesicles can form on the elbows and hocks of pigs

housed on rough surfaces. Depending on the severity of vesicles, the horn of the foot may completely slough off and cause chronic lameness in recovered pigs.

Young pigs, < 14 weeks old, may die without clinical signs of illness because of virus-induced myocarditis; this is more frequent in pigs than in calves (Davies 2002).

Clinical signs of FMD in sheep and goats can be largely inapparent. However, lameness is usually the first, if nonspecific, clinical sign of FMD infection observed in sheep and goats. This is followed by fever and vesicular development on the interdigital cleft, heel bulbs, coronary band, and mouth. Vesicles can also form on the teats of lactating animals and rarely on the vulva and prepuce.

Secondary infections result in decreased milk production, chronic lameness, and predisposition to other viral infections, including sheep pox and goat pox and peste des petits ruminants (WOAH Terrestrial Animal Health card, 2025). Infection in immature sheep and goats, similar to that in young pigs, can cause heart failure and result in death without clinical signs. FMD infections in wildlife resemble clinical illness in their domestic counterparts; however, more severe lesions, such as sloughing of antlers or toe horn, are reported. Severe disease in Asian elephants has been reported, but African elephants appear not to be susceptible.

2.11 Laboratory Diagnosis

The accurate diagnosis of FMD is important for the control and eradication of FMD in endemic areas (Longjam *et al.*, 2011). There are several diagnostic tests to run and these include; Real-time RT-PCR assay, virus isolation, ELISA, or lateral flow devices for antigen detection and virus neutralization tests for antibody detection

In cattle and pigs, clinical signs of FMD are indistinguishable from those of vesicular stomatitis, and in pigs they resemble clinical signs of swine vesicular disease, vesicular exanthema, and Seneca Valley virus disease. Other diseases that can be clinically similar include malignant catarrhal fever, mucosal disease, bluetongue, epizootic haemorrhagic disease, and contagious ecthyma (Orf). Therefore, any vesicular disease in cloven-hoofed animals requires a diagnostic investigation by a suitable laboratory.

The tissue of choice for FMD virus isolation is vesicular epithelium from a fresh lesion. Vesicular fluid contains large amounts of virus as well; however, it is very difficult to

collect in practice. At least 1 g of epithelium should be placed in a transport medium of phosphate-buffered saline solution or equal parts glycerol and phosphate buffer at pH 7.2–7.6. Samples should be kept refrigerated or transported on ice.

If vesicles are not present, oropharyngeal fluid can be collected via probang cup. During acute FMD infection, the virus and viral RNA are also readily detectable in saliva and on oral or nasal swabs.

Serum samples can also be tested (WOAH Terrestrial Animal Health Code 2024), but viremia is fairly short-lived (a few days); thus, when lesions are healing, FMD virus has already been cleared from the blood, and only antibodies can be detected. Repeated sampling of oropharyngeal fluid might be necessary to identify a carrier, because virus presence in such animals is low and fluctuates.

Primary laboratory diagnosis of FMD is usually performed by real-time RT-PCR assay; two separate assays targeting different regions of the RNA genome are commonly used. These assays are very sensitive and can detect FMDV genome even in poorly stored samples when virus infectivity has been lost. In epithelial homogenate prepared from fresh lesions, the presence of virus can also be demonstrated using an antigen ELISA, and this can determine the serotype.

In reference laboratories, sequencing of part of the genome (encoding the capsid proteins, particularly VP1) is frequently performed to determine the serotype and lineage of the strain. Concurrent virus isolation may be performed in appropriate cell culture systems. Commercially available lateral flow devices for rapid detection of virus antigen at the pen-side have proven useful in endemic settings. The devices' use in FMD-free areas must be carefully controlled to ensure that their lower sensitivity compared to real-time RT-PCR detection of viral RNA does not compromise the rapid detection of a virus intrusion. Negative results obtained with a lateral flow device always require laboratory confirmation with a more sensitive test. In FMD-free countries, lateral flow devices for FMD detection should be used exclusively by the veterinary services and not by private veterinarians or farmers. (WOAH Terrestrial manual, 2025).

Serological tests for FMD are used to certify animals for trade, to confirm suspected cases of FMD, test efficacy of vaccination, and provide evidence for absence of infection. Test

cutoffs may be set at different levels for herd-based surveillance versus certifying freedom of infection for trade purposes (WOAH Terrestrial Animal Health Code 2024)

The choice of serological test depends on the vaccination status of the animals.

Serological tests for antibodies against the structural (capsid) proteins of the virus (neutralization tests or ELISAs) cannot reliably detect infection in vaccinated animals because FMD vaccines induce antibodies against these proteins (WOAH Terrestrial Animal Health Code 2024).

ELISA detection of antibodies against the nonstructural proteins, which are produced only during virus replication, can be used to determine past or present infection with any of the 7 serotypes, whether or not the animal has been vaccinated. However, ELISA detection of antibodies against the nonstructural proteins is less sensitive than serological tests for antibodies against the structural (capsid) proteins of the virus and can result in false negatives in cases with limited virus replication, such as vaccinated animals that become infected, because the vaccine suppresses viral replication

2.11.1 Antigen detection tests

A) virus isolation

The virus is propagated in susceptible cell cultures (primary cell cultures such as bovine thyroid cells and porcine or ovine kidney cells) or cell lines such as BHK or IBRS2. The cell cultures are examined for cytopathic effects for 48 hours. The cytopathic effect is indicative of the virus, especially, when the levels of the virus are low. The absence of apparent growth does not guarantee the absence of the virus and therefore samples collected from a suspected case of FMD should be subject to further investigations (Jamal & Belsham, 2013).

B) Real-time Reverse transcription-polymerase chain reaction (RT-PCR)

This is used for detecting FMDV RNA in the epithelium, cell culture isolates and other tissues. Serotype-specific primers have since been designed for the detection of all seven FMDV serotypes by RT-PCR. Primers designed for these assays target various regions of the virus genome, including the 5' UTR, the open reading frame and the 3'UTR (Jamal & Belsham, 2013). In order to improve the diagnostic sensitivity of RT-PCR, multiplex assays, incorporating more than one set of primers have been developed. Recently, real-

time RT-PCR methods have been developed which do not require post- PCR processing for example gel-analysis and the signals can be monitored directly as the target DNA is being amplified (WOAH Terrestrial Animal Health code, 2025). The speed and accuracy of detection of the rRT-PCR assay was further improved by coupling the assays with robotic methods for extraction of nucleic acid from the samples and for set up of the assays. However, these are not designed to discriminate between serotypes of FMDV (Jamal & Belsham, 2013).

2.11.2 Antibody detection test

Virus neutralization test: this is currently considered the gold standard for the detection of antibodies to structural proteins of FMDV. However, its more prone to variability than other serological tests because various primary and cell line with variable degrees of sensitivities are used. This is also slower, subject to contamination and requires restrictive biocontainment facilities in contrast to other serological test which can use inactivated viruses as antigens (Jamal & Belsham, 2013).

2.12 Control of Foot and Mouth disease

There have been various ways of controlling the disease world wide. These ways include; Culling, Animal movement controls, Vaccination and Supportive care (no specific treatment). In regions that are normally FMD-free, control of the disease is typically attempted by culling all animals on infected premises, and animal movement controls are imposed to decrease the risk of virus spread (WOAH Terrestrial Animal Health Code, 2024). In both normally FMD-free regions and endemic areas, vaccination around outbreaks may be used to limit the spread of the disease (WOAH Terrestrial Animal Health card, 2025). No treatments for infected animals are available. There is no specific treatment for FMD; however, supportive care may be allowed in countries where FMD is enzootic (WOAH Terrestrial Animal Health Code, 2024).

WOAH classifies countries and regions as free from FMD where vaccination is not practiced; free from FMD where vaccination is practiced; suspended status; or no status. FMD-free countries are often reluctant to use vaccination for outbreak control. There is a concern that carrier animals induced by clinically inapparent FMDV infection of vaccinated animals can remain undetected by postvaccination serological testing. Therefore, vaccinated animals, even those without detectable antibodies against non-

structural proteins of FMDV, are often culled as a precautionary measure after the outbreak has been contained (WOAH Terrestrial Animal Health Code, 2024). However, this allows countries to regain FMD-free status without additional delay even if vaccinated animals remain in the national herd, as long as stringent surveillance requirements are met.

Inactivated virus vaccines protect for only 4–6 months against the specific serotypes contained in the vaccine. Billions of doses are used each year and protect animals from clinical illness but not viral persistence in the pharyngeal region (of cattle), and thus vaccinated animals can be carriers of infectious FMD virus. Additionally, distinguishing infected animals from vaccinated animals is difficult unless costly purified vaccines are used (WOAH Terrestrial Animal Health Code, 2025).

When mass culling is performed, infected carcasses must be disposed of via incineration, burial, or rendering on or close to the infected premises. Scavengers and rodents should be controlled to prevent mechanical dissemination of virus. Buildings should be cleaned and disinfected with an acidic or alkaline disinfectant, and people who have come into contact with virus must decontaminate their clothing and avoid contact with susceptible animals for a period of time (Alexandersen *et al.*, 2003; Davies, 2002).

In some regions, FMD persistence in wildlife populations, such as African buffalo, can make FMD eradication very difficult. Control measures, such as fencing of wildlife reserves to prevent contact with domestic livestock, have helped limit the spread of virus in certain areas. A twice-yearly vaccination buffer zone in livestock near endemic wildlife reserves could additionally help decrease outbreaks.

2.13 Progressive Control Pathway for FMD

As with all infectious diseases, good on-farm biosecurity is very important for the protection of herds against the introduction of FMDV. A progressive control pathway has been developed by the UN's Food and Agriculture Organization (FAO) and adopted by WOAHA to enable countries to improve their FMD control so that the global disease situation will improve.

Stage 0. This consists of countries where the disease is endemic and have no reliable information on the disease status (WOAH Terrestrial Animal Health Code, 2024; Jamal & Belsham, 2013).

Stage 1. This consists of countries with a comprehensive study on the epidemiology of FMD planned. This assists in identifying and developing appropriate control options in at least one animal production sector (Jamal & Belsham, 2013).

Stage 2. This stage involves the implementation of a risk-based FMD control plan/ chosen policy to reduce disease in at least one animal production sector.

Stage 3. An aggressive strategy to eliminate FMD in at least one region/ production system needs to be adopted (Jamal & Belsham, 2013).

Stage 4. This requires that FMD is controlled to an extent that it is not endemic in domestic livestock (FMD free status with vaccination) for the whole or part of the country. If a country decides to continue along the FMD-PCP to stage 4 and beyond. It may ask the OIE for an endorsement of its national FMD eradication program. Countries in stage 4 have maintained zero circulation with no incursions of FMD (WOAH Terrestrial Animal Health card, 2025).

2.14 FMD control protocol and Vaccination strategies in Uganda

FMD is a notifiable disease that should be reported within 48 hours of the outbreak. Any person responsible for animals is obliged by the Animal Diseases Act and the Food and Drugs Act 2026 to report disease outbreaks that occur in their herds. The farmer reports disease within 24 hours through his or her local veterinary doctor to the district veterinary officer who undertakes a clinical investigation and reports to commissioner within the next 24 hours.

The commissioner constitutes an investigation team composed of an epidemiologist and laboratory scientists and reports are sent to all stakeholders (Farmer, local veterinary, MAAIF administration, AU IBAR, OIE). Finally, after confirming that it's FMD, ring vaccination with an appropriate vaccine is instituted immediately (Rutebarika, 2012)

In Uganda, FMD outbreaks are controlled by quarantine and ring vaccination of cattle for more than 25 years (Balinda *et al.*, 2009; Mwiine, 2019). The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) oversee disease management through quarantine controls, animal movement regulations, and strategic vaccination programs (Mugezi *et al.*, 2020). Animal Health Authorities have used a trivalent FMD vaccine containing serotypes O, SAT 1, and SAT 2, which is manufactured in Kenya (KEVEVAP1) for the vaccination

of animals. However, the success of these efforts is affected by several systemic challenges; uncontrolled animal movements, inadequate surveillance and delayed reporting (Namatovu *et al.*, 2015), misidentification of vaccination benefits and confusion between therapeutic treatments (e.g., antibiotics) and preventive vaccines also remain prevalent (Nakkazi, 2022; Ochieng *et al.*, 2024), reactive approach of vaccination implemented as a reactive "fire brigade" measure during ongoing outbreaks rather than a systematic, routine preventive regime, cost and supply chain disruption, delayed vaccine deployment and reliance on imported emergency supplies (Muleme *et al.*, 2012; Mugezi *et al.*, 2020), short shelf-life of FMD vaccines and their requirements of uninterrupted cold-chain logistics, which are difficult to maintain in rural and semi-urban settings with limited infrastructure (UPDF, 2024). These challenges make the nationwide vaccination coverage suboptimal often below 50% in affected regions (Balinda *et al.*, 2009; WRLFMD, 2025).

2.15 Economic importance of FMD

FMD is the world's most important animal disease, even though the mortality rate is low, losses occur in many ways of production, the expense of eradication and interference with movement of livestock and meat between countries are the most important economic effects (Radostits, 2009). In Uganda, all actors along the cattle marketing chain incur losses during FMD outbreaks, but smallholder farmers are most affected for example, Farmers with small and medium herds incurred higher control costs, whereas large herds experienced the highest milk losses. Total income earned by the actors per month at the processing level reduced by 23%. In Isingiro, bulls and cows were salvage sold at 83% and 88% less market value, i.e., a loss of \$196.1 and \$1,552.9 in small and medium herds, respectively (Baluka, 2016). Control and prevention of FMD should remain the responsibility of the government if Uganda is to achieve a disease-free status that is a prerequisite for free movement and operation of cattle markets throughout the year which will boost cattle marketing (Baluka, 2016).

2.16 Factors influencing cattle farmers' knowledge, behaviour and practices on FMD and FMD vaccination

Studies across developing nations indicate varied levels of farmer knowledge regarding FMD. While most smallholders can accurately identify primary clinical signs such as excessive salivation, fever, and mouth or foot lesions (e.g., 77–86%), understanding of

transmission pathways, asymptomatic carriers, and vaccine scheduling is typically low (Osmani *et al.*, 2021; Bayantassova *et al.*, 2023). Misidentification of vaccination benefits and confusion between therapeutic treatments (e.g., antibiotics) and preventive vaccines remain prevalent (Nakkazi, 2022; Ochieng *et al.*, 2024).

Attitudes toward vaccination programs are heavily influenced by perceived vaccine safety, efficacy, cost, and government trust (Roth, 2011; Bayantassova *et al.*, 2023). Misinformation, fear of adverse post-vaccination reactions, and perceived vaccine failure often caused by cold-chain breakdown or strain mismatch foster negative attitudes and reluctance to participate in vaccination campaigns (Muleme *et al.*, 2012; Nakkazi, 2022).

Regular adoption of preventive FMD vaccination remains low globally among resource-constrained smallholders, with reported routine vaccination rates between 21% and 46% in similar international settings. Common behavioural practices during outbreaks include reliance on self-treatment using unverified remedies, failure to isolate infected stock, or distress-selling of animals, which accelerates viral spread (Osmani *et al.*, 2021; Bayantassova *et al.*, 2023). Major reported barriers include: High vaccination costs (Baluka, 2016), Inadequate access to qualified veterinary extension services (Nakkazi, 2022), Irregular distribution of vaccines by MAAIF (Muleme *et al.*, 2012).

2.17 Conceptual Framework and Literature Gap

While KAP studies on livestock diseases have been conducted in regions such as Eastern Uganda, Western Kazakhstan, Afghanistan, and Cambodia, local factors vary significantly depending on farming systems, market access, and urban proximity (Osmani *et al.*, 2021; Bayantassova *et al.*, 2023; Ochieng *et al.*, 2024).

Mukono District, particularly Mukono Central Division, represents a unique peri-urban farming ecosystem characterized by high livestock density, proximity to major urban markets (e.g., Kampala), and high volumes of livestock transit (UBOS, 2024; NLC, 2021). Despite historical FMD occurrences in Mukono, there is a lack of empirical baseline data on cattle farmers' specific knowledge levels, attitudes, and current vaccination practices in Mukono Central Division. This literature gap hinders the design of tailored veterinary extension programs and targeted policy interventions.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Mukono Central Division, located in Mukono municipality, Mukono district which is adjacent to the Capital City, Kampala. The division is about 27 kilometers (17 mi) by Kampala- Jinja high in the East of Kampala City. It occupies approximately 31.4 square kilometers (12.1 sq mi) of land area with a major busy highway, Kampala-Jinja that connects cities in the central, eastern, and Northern part of the country including the capital city (Kampala) of Uganda and it is used for transportation of livestock from places to places.

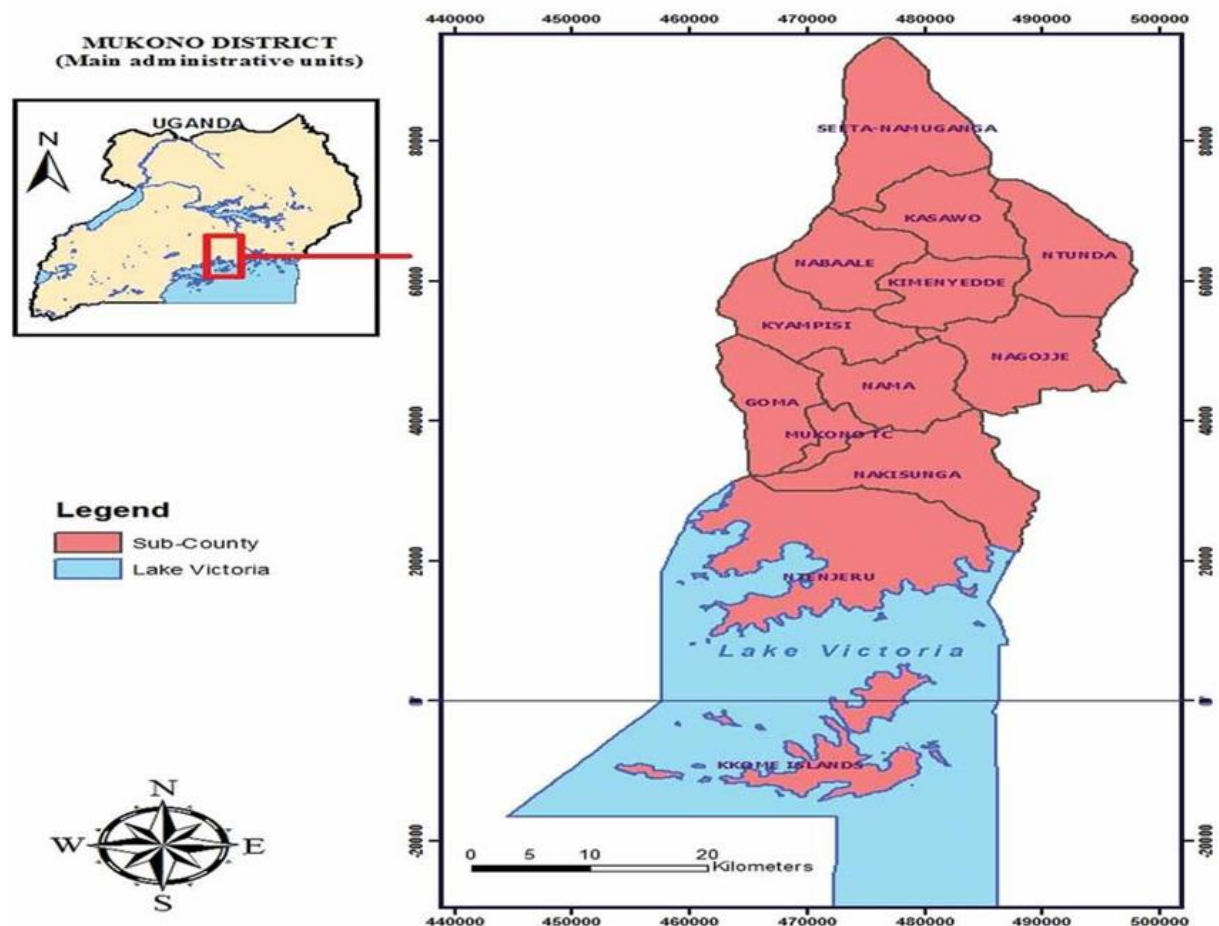


Figure 1: Map of Mukono District

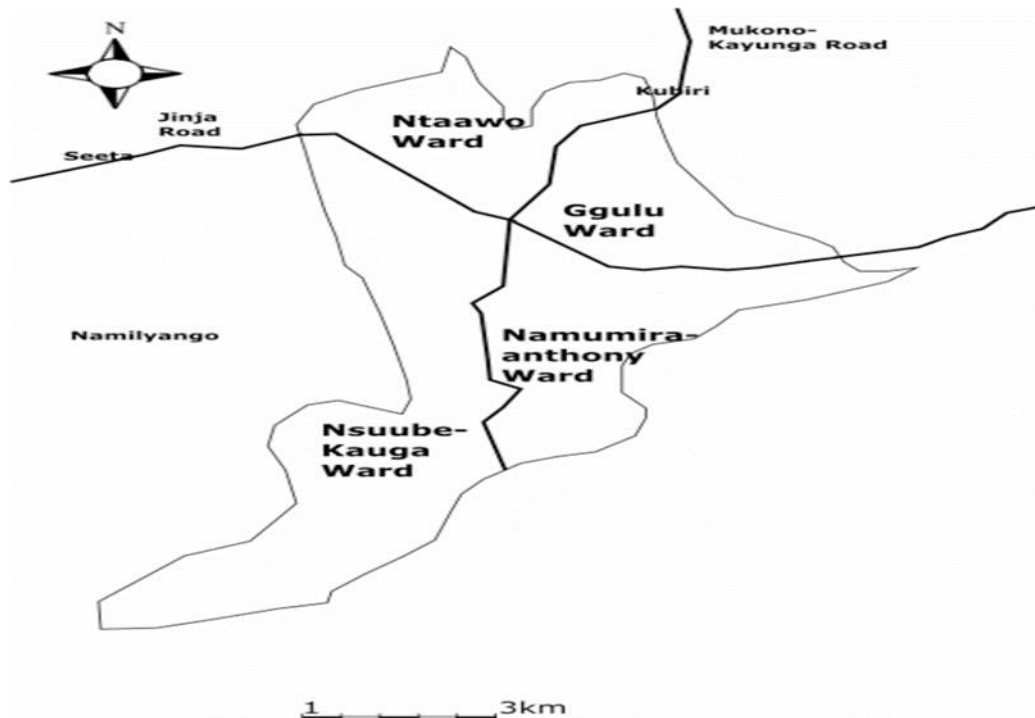


Figure 2: Map of Mukono Central Division Showing the Four Wards/Parishes

3.2 Study Design

A cross-sectional study was conducted from January partly, June, July and August using structured questionnaires covering sociodemographic parameters, knowledge on FMD, attitudes toward vaccination, prevention practices, and perceived barriers by cattle farmers from Mukono Central Division.

3.3 Data collection

A structured questionnaire was given to each cattle farmer from their homes or farms and interviewed. Prior to administering the questionnaire, the purpose of the study was outlined, a brief explanation of FMD was provided orally by the author and a consent form to participate in the study was obtained voluntarily. This was done in the morning or late afternoon depending when the farmer was at home. The questionnaire had four sections; first section had socio-demographic information, second section had knowledge on FMD, third section was attitude towards FMD vaccination and lastly practices regarding FMD vaccination. Before interview commencement, a thorough description of each section was explained to farmers and where necessary, a local language for example “kalusu” to mean FMD, “omusomo” (training) etc. was used to translate the questions to the farmer to be able to have accurate information on interview

3.4 Sample size determination and sample selection

The sample size was determined using the formula (Leslie Kish formula) $n = Z^2PQ/d^2$, where; n is the required sample size, Z is the standard normal deviate at the 95% confidence level (1.96), P is the estimated proportion of the population with the characteristic of interest, $Q=1-P$, and d is the desired margin of error (level of precision)

$Z=1.96$ for 95% confidence interval

Assumptions

$P = 0.50$, because this gives the maximum sample size when the true proportion is unknown

$Q=1-P=0.50$

$d = 0.05$ margin of error.

Then; $n = Z^2PQ/d^2 = (1.96)^2 * (0.5) * (0.5) / (0.05)^2$
 $n=384$.

However, from the study the predetermined $n=158$, enhance the adjusted sample size determination calculation with $d=0.078$ (7.8% precision) as the margin of error.

Then:

$$\begin{aligned} n &= Z^2PQ/d^2 \\ n &= (1.96)^2 * (0.50) * (0.50) / (0.078)^2 \\ n &= 3.8416 \times 0.250006084 \\ n &= 158.07 \approx 158 \end{aligned}$$

Therefore: $n=158$

A multi-stage sampling technique will be used to select cattle farmers for the study. In the first stage, parishes within Mukono Central Division will be identified and selected. In the second stage, villages within the selected parishes will be randomly selected. In the third stage, households keeping cattle were identified from the selected villages and randomly sampled for participation in the study. Within the selected households, eligible cattle farmers were identified and selected using random sampling procedures basing on the

inclusion criteria, and if the farmer was willing to participate in the study, until the predetermined sample size is reached.

3.4.1 Inclusion and Exclusion criteria

The farmer was eligible for the study if he was a resident within Mukono Central Division, owning, actively and directly managing cattle daily, aged 18 years or older and willing to participate in the study and was excluded if he was a non-resident

3.4 Data Analysis

Data obtained from the questionnaires were entered into an excel worksheet (Microsoft® Excel for office 16). Data management and analyses were carried out in MS Excel and Statistical software. Descriptive statistics were used to summarise the data. Frequencies and percentages were calculated for categorical variables, while means, standard deviations, minimum and maximum values were calculated for continuous variables. Multiple-response questions were analysed by counting the number of respondents who mentioned each response. Consequently, percentages for multiple-response variables did not necessarily sum to 100%. Questions on knowledge were used to determine the farmers' general knowledge regarding the disease, its clinical signs, and modes of transmission. Questions on attitudes and practices were used to assess farmers, perceptions on vaccination, and its effectiveness, barriers or concerns regarding FMD vaccination, control measures and disease prevention methods respectively. The main outcome variable for inferential analysis was FMD vaccination status, categorised as vaccinated or not vaccinated. Chi-square tests of independence were used to determine associations between vaccination status and selected categorical variables. Independent-samples comparisons were used for continuous variables, specifically age and number of cattle owned. Statistical significance was assessed at the 95% confidence interval (95% CI) with 5% level, where $p < 0.05$ was considered statistically significant.

3.5 Ethical Considerations

Permission to carry out this research in Mukono central Division was sought from and granted by District Veterinary Officer following introduction of the research letter, by the dean School of Veterinary Medicine and Animal Resources-COVAB to the aforementioned authority.

I provided an informed consent from all participants before data collection, understanding the purpose and potential impact of the research seeking their voluntary participation with no coercion or pressure.

3.6 Limitations of the study

Although this survey collected valuable information, there were potential limitations in its application. Recall Bias: Some farmers were not accurately remembering the past FMD outbreaks, vaccination schedules, or treatment details, which affected the reliability of self-reported data on vaccination practices. Some farmers also did not have a basic knowledge of hygiene to adopt in their cattle herds, despite raising cattle for many decades and having close communication with veterinary professionals. Similarly, even though most of the farmers were well-aware of the damages caused by FMD, some were reluctant to provide detailed information about it.

CHAPTER FOUR

RESULTS

4.1 Demographic characteristics of the surveyed cattle farmers

A total of 158 farmers participated in the study. 81 (51.3%) respondents were male, while 77 (48.7%) were female. This indicates that both sexes were adequately represented in the study. The largest proportion of respondents, 45 (28.5%), had attained secondary education. This was followed by those with primary education, 40 (25.3%), and tertiary education, 39 (24.7%). 34 respondents (21.5%) had no formal education. The findings therefore demonstrate variation in educational attainment among the respondents. More than half of the respondents, 80 (50.6%), had more than five years of farming experience. 40 respondents (25.3%) had between one and five years of experience, while 38 (24.1%) had less than one year of farming experience. Thus, the study population was predominantly composed of respondents with relatively substantial farming experience. The mean age of respondents was 38.55 years, with ages ranging from 26 to 60 years. The mean number of cattle owned was 15.35, with a minimum of 6 and a maximum of 30 cattle. The results indicate that the respondents represented a relatively broad adult age range and varying herd sizes. Zero grazing was the predominant production system, reported by 132 (83.5%) respondents. Only 26 (16.5%) reported using communal grazing. This indicates that most respondents managed cattle under a zero-grazing system. Furthermore there were significant associations between vaccination status and farming experience, age, and number of cattle owned. Farming experience showed an increasing vaccination proportion across the categories, from 15.8% among respondents with less than one year of farming experience to 53.8% among those with more than five years.

Table 1: Demographic characteristics of the surveyed cattle farmers

Variable	Category	n/ (%)	Vaccinated n (%)	Not vaccinated n (%)	χ^2 / t	p-value
Sex	Male	81 (51.3)	29	52	1.152	0.283
	Female	77 (48.7)	35	42		
Education	Never attended school	34 (21.5)	38.2	61.8	4.042	0.257
	PLE	40 (25.3)	47.5	52.5		
	O/A' level	45 (28.5)	46.7	53.3		
	University/	39 (24.7)	28.2	71.8		
	Tertiary					
Farming experience	<1 year	38 (24.1)	15.8	84.2	15.606	0.0005*
	1–5 years	40 (25.3)	37.5	62.5		
	>5 years	80 (50.6)	53.8	46.2		
Age	Mean $\pm$ SD	—	40.45	37.26	t = 2.426	0.017*
Cattle owned	Mean $\pm$ SD	—	17.73	13.73	t = 4.431	0.0046*
Grazing system	Zero grazing	132 (83.5)	37.1	62.9	3.008	0.083
	Communal grazing	26 (16.5)	57.7	42.3		

Key: n – frequency, % - proportion, χ^2 -chi square, t-test, p-value; statistical significance level, *significant ($P < 0.05$)

4.2 Knowledge of cattle farmers regarding FMD

All 158 respondents (100%) reported having heard of FMD, 119 (75.3%) reported that their herds had previously been affected by FMD, while 39 (24.7%) had not experienced FMD in their herds. The results demonstrate universal awareness of FMD and its vaccination among the respondents, while previous herd exposure to the disease was also common. Multiple responses were permitted for clinical signs; blisters in the mouth were the most frequently recognised clinical sign, identified by 99 (62.7%) respondents, followed by hypersalivation at 94 (59.5%). Fever was identified by 80 (50.6%) respondents, while lameness was identified by 79 (50.0%). The results indicate that respondents were able to recognise several important clinical manifestations of FMD, although recognition was not universal for any individual sign. Further more, multiple responses were permitted; direct transmission was the most frequently recognised transmission route, reported by 120 (75.9%) respondents, airborne transmission was identified by 75 (47.5%), while transmission through equipment was identified by 33 (20.9%). The findings indicate stronger recognition of direct transmission compared with other possible transmission pathways. More than half of respondents, 86 (54.4%), identified goats as other animals affected by FMD. 34 (21.5%) identified both goats and

sheep, while 38 (24.1%) did not know other affected species. The findings indicate that although knowledge of susceptible species existed among many respondents, approximately one-quarter lacked this information. All respondents had heard of FMD and reported knowledge of FMD vaccination, meaning these variables had no variation and therefore could not provide a meaningful chi-square association. Previous occurrence of FMD in the herd was not significantly associated with vaccination status. However, knowledge of other animal species affected by FMD was significantly associated with vaccination status ($\chi^2 = 9.257$, $p = 0.010$). Respondents who identified goats had a vaccination proportion of 50.0%, compared with 21.1% among those who did not know other affected species.

Table 2: Knowledge of cattle farmers regarding FMD clinical signs, transmission and species affected

Variable	Response	n/ (%)	Vaccinated n (%)	Not vaccinated n (%)	χ^2	p-value
Heard of FMD	Yes	158(100)	—	—	—	—
Herd	Yes	119(75.3)	38.7	61.3	0.409	0.522
previously affected	No	39(24.7)	46.2	53.8		
Clinical signs*	Blisters in mouth	99(62.7)	—	—	—	—
	Hypersalivation	94(59.5)	—	—		
	Fever	80(50.6)	—	—		
	Lameness	79(50.0)	—	—		
Transmission routes*	Direct transmission	120(75.9)	—	—	—	—
	Airborne transmission	75(47.5)	—	—		
	Equipment	33(20.9)	—	—		
Other animal species	Goats	86(54.4)	50.0	50.0	9.257	0.010*
	Goats and sheep	34(21.5)	38.2	61.8		
	Don't know	38(24.1)	21.1	78.9		

Key: *Multiple responses were permitted, so percentages do not total 100%. n – frequency, % - proportion, χ^2 -chi square, p-value; statistical significance level, *significant($P < 0.05$)

4.3 Attitudes of cattle farmers regarding FMD

The results show that 81 farmers (51.3%) considered FMD vaccination very important, while 77 farmers (48.7%) considered it somewhat important. This indicates that all respondents recognized vaccination as having some importance, although approximately half did not regard it as extremely important. Regarding the effectiveness of FMD

vaccination, 43 farmers (27.2%) agreed that vaccination was effective and 38 farmers (24.1%) strongly agreed. Together, these respondents represented 51.3% of the study participants. However, 40 farmers (25.3%) were neutral and 37 farmers (23.4%) disagreed. Cost was the most frequently reported concern, accounting for 43 (27.2%) respondents. Concerns about effectiveness were reported by 40 (25.3%), while 38 (24.1%) were concerned about side effects. Access alone was reported by 21 (13.3%), while 16 (10.1%) identified both cost and access.

Perceived importance of FMD vaccination was not significantly associated with vaccination status ($p = 0.671$). Whereas both perceived vaccine effectiveness and whereas respondents' main concerns about vaccination were significantly associated with vaccination status ($p = 0.019$) and ($p = 0.002$) respectively.

Table 3: Attitudes of the cattle farmers toward FMD vaccination

Variable	Response	n/ (%)	Vaccinated (%)	Not vaccinated (%)	χ^2	p-value
Perceived importance	Very important	81(51.3)	38.3	61.7	0.180	0.671
	Somewhat important	77(48.7)	42.9	57.1		
Perceived effectiveness	Agree	43(27.2)	53.5	46.5	9.896	0.019*
	Neutral	40(25.3)	47.5	52.5		
	Strongly agree	38(24.1)	21.1	78.9		
	Disagree	37(23.4)	37.8	62.2		
Main concerns	Cost	43(27.2)	41.9	58.1	16.741	0.002*
	Effectiveness	40(25.3)	47.5	52.5		
	Side effects	38(24.1)	21.1	78.9		
	Access	21(13.3)	71.4	28.6		
	Cost and access	16(10.1)	25.0	75.0		

Key: n – frequency, % – proportion, χ^2 -chi square, p-value; statistical significance level, *significant ($P < 0.05$)

4.4 Practices and Barriers to FMD vaccination among the sampled cattle farmers

The study shows that 64 (40.5%) respondents reported that their cattle had been vaccinated, whereas 94 (59.5%) reported that their cattle had not been vaccinated. This finding is notable because awareness of FMD vaccination was reported by all respondents. Veterinary officers were reported as responsible for vaccination by 90 (57.0%) respondents, while 68 (43.0%) reported para-veterinarians. The findings demonstrate that vaccination was predominantly undertaken by trained animal-health personnel. Only 67 (42.4%) respondents considered FMD vaccination affordable and a total of 91 (57.6%) considered it expensive or very expensive/inaccessible. The majority of respondents

experienced difficulties accessing vaccination services. 70 (48.7%) described access as difficult and 43 (27.2%) as very difficult, totalling to 120 (75.9%) respondents experienced some degree of difficulty, while only 38 (24.1%) reported that vaccination was easy to access. Both affordability and accessibility were significantly associated with vaccination status. The majority of respondents, 105 (66.5%), had not received training related to FMD, while only 53 (33.5%) had received training. This indicates that formal training was not widespread among the respondents. Among all respondents, 26 (16.5%) reported that training was very useful and 27 (17.1%) considered it somewhat useful. The majority, 105 (66.5%), had not attended training. The respondents obtained FMD-related information through several channels. The largest category was veterinary services and media, reported by 43 (27.2%) respondents, followed by farmers at 40 (25.3%). Veterinary services and extension were reported by 38 (24.1%), while farmers and media were reported by 37 (23.4%). The findings demonstrate that both professional and informal information channels contributed to respondents' access to FMD-related information.

Table 4: Practices and barriers to FMD vaccination among the sample cattle farmers

Variable	Response	n/ (%)	Vaccinated (%)	Not vaccinated (%)	χ^2	p-value
Vaccination status	Yes	64 (40.5)	—	—	—	—
Frequency	No	94 (59.5)	—	—	—	—
	Only during outbreaks	158 (100)	—	—	—	—
Source of vaccine	Veterinary officer	158 (100)	—	—	—	—
	Veterinary officer	90 (57)	—	—	—	—
Person vaccinating	Para-veterinarian	68 (43)	—	—	—	—
Affordability	Affordable	67 (42.4)	56.7	43.3	14.215	0.000
	Expensive	53 (33.5)	34.0	66.0		6*
	Very expensive	38 (24.1)	21.1	78.9		
Accessibility	Easy	38 (24.1)	21.1	78.9	9.151	0.010
	Difficult	77 (48.7)	42.9	57.1		*
	Very difficult	43 (27.2)	53.5	46.5		
Training received	Yes	53 (33.5)	35.8	64.2	0.456	0.499
	No	105 (66.5)	42.9	57.1		
Training usefulness	Very useful	26 (16.5)	—	—	—	—
	Somewhat useful	27 (17.1)	—	—	—	—
	Did not attend	105 (66.5)	—	—	—	—
Information source	Veterinary services and media	43 (27.2)	—	—	—	—
	Farmers	40 (25.3)	—	—	—	—
	Veterinary services and extension	38 (24.1)	—	—	—	—
	Farmers and media	37 (23.4)	—	—	—	—

Key: n – frequency, % – proportion, χ^2 – chi square, p-value; statistical significance level, *significant ($P < 0.05$)

Nearly half of respondents, 77 (48.7%), were not sure how long FMD clinical signs take to heal. 40 (27.8%) reported a period exceeding two weeks, while 37 (23.4%) reported one to two weeks. The relatively high proportion of uncertain responses suggests that knowledge regarding the clinical duration of FMD was incomplete among respondents.

Milk loss and animal death were the most frequently reported consequences of FMD, each reported by 61 (38.6%) respondents. Meat loss was reported by 40 (25.3%), while market-value loss was reported by 8 (5.1%). The findings demonstrate that respondents associated FMD with both production and economic consequences.

Table 5: Clinical and economic effects of FMD

Variable	Response	n/ (%)
Period for clinical signs to heal	1–2 weeks	37 (23.4)
	More than 2 weeks	44 (27.8)
	Not sure	77 (48.7)
Reported losses*	Milk loss	61 (38.6)
	Animal death	61 (38.6)
	Meat loss	40 (25.3)
	Market-value loss	8 (5.1)

*Key: *Multiple responses were permitted. n – frequency, % - proportion*

The area veterinary officer was the most frequently reported recipient of FMD reports, accounting for 89 (56.3%) respondents. 69 (43.7%) reported cases to the district veterinary officer. This indicates that veterinary authorities were the main reporting channels used by respondents. Half of the respondents, 80 (50.6%), reported that they received a response within two weeks. 40 (25.3%) reported receiving a response after more than two weeks, while 38 (24.1%) were unsure about the response time. The results demonstrate variation in the reported timeliness of response following disease reporting.

Disinfection of premises was the most commonly reported disease-control intervention, identified by 97 (61.4%) respondents. Strict control of cattle buying was reported by 79 (50.0%), while veterinary inspection was reported by 53 (33.5%). These findings indicate that respondents reported the use of several complementary disease-control approaches. Inspection was the most frequently reported additional intervention, identified by 123 (77.8%) respondents. Quarantine was reported by 81 (51.3%), isolation by 77 (48.7%), and disinfection by 35 (22.2%). The findings indicate that inspection, quarantine and isolation were commonly recognised or implemented disease-control measures.

Table 6: Disease Reporting, Response time and Control Measures

Variable	Response	n/ (%)	Vaccinated (%)	Not vaccinated (%)	χ^2	p-value
Reporting authority	Area veterinary officer	89(56.3)	—	—	—	—
	District veterinary officer	69(43.7)	—	—		
Response time	Within two weeks	80(50.6)	46.2	53.8	7.875	0.020*
	More than two weeks	40(25.3)	47.5	52.5		
	Not sure	38(24.1)	21.1	78.9		
Control interventions*	Disinfection of premises	97(61.4)	—	—	—	—
	Strict control of cattle buying	79(50.0)	—	—		
	Veterinary inspection	53(33.5)	—	—		
Other interventions*	Inspection	123(77.8)	—	—	—	—
	Quarantine	81(51.3)	—	—		
	Isolation	77(48.7)	—	—		
	Disinfection	35(22.2)	—	—		

Key: * Multiple responses were permitted. n – frequency, % - percentage, χ^2 -chi square, p-value; statistical significance level, *significant($P < 0.05$)

CHAPTER FIVE

DISCUSSION

All 158 farmers were aware of the existence of FMD and had heard of FMD vaccination, which indicates high general awareness of the disease within the Mukono Central Division. However, knowledge regarding disease symptoms, modes of transmission, and susceptible host species varied considerably among farmers. Regarding clinical signs, farmers recognized several common manifestations, including mouth blisters, excessive salivation, fever, and lameness, Similar to Jost *et al.*, (2007) who reported that farm owners are usually aware of the apparent clinical signs of the disease in both their own and neighboring livestock. The recognition of mouth blisters and hypersalivation as primary signs of FMD is also similar to recent studies from S.E. Asia, in countries like; Afghanistan, Kazakhstan, and Cambodia, and reveal common gaps in KAP; where 77-86% farmers identified salivation and lesions in the mouth as primary clinical signs of FMD, (Osmani, Habib, & Robertson, 2021; Bayantassova *et al.*, 2023). However, the relatively low proportion of farmers identifying fever and lameness shows a difference in the two studies which suggests that some livestock owners may not recognized the early-stage infection leading to delayed isolation of sick animals, allowing the virus to spread rapidly within herds. In terms of transmission, a majority of participants correctly identified direct contact with infected animals as the primary mode of disease spread, similar to a recent study in Uganda which reported that 47.9% of cattle farmers knew that FMD is transmitted through direct contact between infected and non infected animals (Kirabira, 2022). When asked about other susceptible species, more than half knew goats while one quarter were unaware that other species could contract FMD. Given that small ruminants like goats and sheep often present with mild or asymptomatic FMD infections while acting as silent reservoirs (Kitching & Hughes, 2002; Thornley&France,2009), a lack of awareness regarding these species poses a risk. Farmers who manage mixed-species farms without recognizing the risk from small ruminants may inadvertently allow the virus to persist within their livestock. Importantly, knowledge of other affected species was significantly associated with vaccination status. Another important finding was that 48.7% of respondents were unsure about the period required for FMD clinical signs to heal. This provides additional evidence that although awareness of FMD was universal, detailed knowledge was incomplete thus more regular farmer education on the complete range of FMD signs, transmission routes and other susceptible species should be

conducted through use of local languages, pictorial materials, and practical demonstrations.

More than half of the farmers considered FMD vaccination very important, while the remainder considered it somewhat important. This demonstrates a generally positive attitude toward vaccination. The finding is encouraging because recognition of the importance of vaccination is a key step toward improving vaccination uptake. However, the fact that 48.7% of respondents selected “somewhat important” suggests that many farmers may not fully appreciate the consequences of FMD. Only 51.3% of farmers agreed or strongly agreed that FMD vaccination was effective. The remaining respondents were either neutral or disagreed. Farmers’ perceptions of FMD vaccination effectiveness varied. However, both the perceived vaccination effectiveness and concerns about vaccination were significantly associated with vaccination status. The survey revealed significant gaps between disease awareness and practical control measures. It suggests that farmers' decisions regarding vaccination were influenced by factors beyond whether they considered vaccination important and this could be reached through targeted education from veterinary officers and successful farmer testimonials, address their concerns about vaccine effectiveness, side effects, benefits and limitations of vaccinating their herds against FMD.

A key finding was that despite a high general awareness of FMD and FMD vaccination among the interviewed cattle farmers, only 40.5% of the surveyed farmers actually vaccinated their cattle against the disease, while 59.5% did not, similar to the recent studies from West Kazakhstan (Bayantassova *et al.*, 2023) where vaccination practices were inconsistent, with only 21-46% vaccinating regularly. All respondents reported that FMD vaccination occurred only during outbreaks. All respondents identified the veterinary officer as the source of the vaccine, while 57.0% reported that veterinary officers conducted vaccination and 43.0% reported vaccination was conducted by para-veterinarians. This demonstrates the central role of animal-health personnel in the vaccination process. Regarding sources of information, farmers relied almost equally on veterinary officers (29.3%), radio programming (29%), fellow farmers (27.9%), and extension workers (13.8%). Affordability emerged as an important barrier and significantly associated with vaccination status with more than half of respondents, vaccination as either expensive or very expensive. Accessibility to vaccination services was another important issue and it was statistically associated with vaccination status.

48.7% described access to vaccination services as difficult and 27.2% described it as very difficult, meaning that a combined 75.9% experienced some degree of difficulty accessing vaccination services. Only 24.1% reported that vaccination was easy to access. Training was another potential component of FMD prevention. However, 66.5% of respondents had not received FMD-related training, while only 33.5% had received training. Among those who received training, respondents considered it useful to some degree. The findings also showed that farmers primarily reported suspected FMD cases to veterinary authorities. This is similar to another KAP study in West Kazakhstan (Bayantassova *et al.*, 2023). Half of the respondents reported receiving a response within two weeks, while 25.3% reported a response taking more than two weeks and 24.1% were unsure about the response time. Response time was significantly associated with vaccination status. Respondents reported several other FMD-control measures, including inspection, quarantine, isolation, disinfection, control of cattle purchasing and veterinary inspection on vaccination. The reported consequences of FMD were mostly milk loss and animal death, followed by meat loss and market-value loss. These findings demonstrate that FMD was perceived as having both production and economic consequences for cattle farmers. The study shows that despite the high general awareness and positive attitude; vaccination adoption remains low. It suggests that providing vaccination services through coordinated community campaigns held near farmers and at convenient times, subsidies or farmer-group cost-sharing for small- and medium-cattle farmers to improve affordability and access to vaccination services and practical demonstrations and farmer meetings to reach farmers with different education levels.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study on the KAPs of cattle farmers, provided helpful information on FMD and FMD vaccination, which could be used to improve the future implementation of methods to control FMD within Mukono Central Division as well as the country. Cattle farmers in Mukono Central Division were aware of FMD and FMD vaccination, However, gaps remained, particularly concerning less commonly recognized transmission pathways, other susceptible species and the clinical manifestation of the disease. The study demonstrated general positive attitude towards FMD vaccination, in that they were willing to register their herds to be vaccinated against FMD, if their, concerns about cost, effectiveness, side effects and accessibility were addressed. Vaccination adoption was relatively limited despite of the positive attitude and the high general awareness of the FMD and its vaccination; the vaccination practice was largely outbreak-oriented. Farmers were able to report the disease cases to veterinary authorities although response time was not well known.

6.2 Recommendations

- Conduct regular farmer education on the complete range of FMD signs, transmission routes and susceptible species to strengthening farmer knowledge
- Use local languages, radio programs, pictorial materials, practical demonstrations and farmer meetings to reach farmers with different education levels.
- Provide vaccination services through coordinated community campaigns held near farmers and at convenient times.
- Consider affordable pricing, subsidies or farmer-group cost-sharing for small- and medium-cattle farmers to improve affordability and access to vaccination services.
- Veterinary authorities should address farmers' concerns about vaccine effectiveness and side effects with clear information about the benefits and limitations of FMD vaccination, address misconceptions and uncertainty about vaccination to improve farmers' confidence in registering their herd for vaccination.

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APPENDICES

Appendix I: Consent Form

INTRODUCTION

I am Katumba David a final student at Makerere University, School of Veterinary Medicine and Animal Resources conducting a research study on:

CATTLE FARMERS' KNOWLEDGE, ATTITUDE, AND PRACTICES REGARDING FMD VACCINATION IN MUKONO CENTRAL DIVISION, MUKONO DISTRICT

The purpose of this study is to assess cattle farmers' knowledge of FMD vaccination and understand attitudes regarding FMD vaccination, identify current practices and barriers to vaccination uptake.

The findings will help improve livestock health programs and inform policy on disease control in Uganda to better understand your experiences and views to help improve vaccination programs and cattle health in this area.

Your participation in this interview/discussion is completely voluntary. You have the right to decline to answer any question or to stop participating at any time without any negative consequences. All the information you provide will be treated with strict confidentiality. Your name or any identifying details will not be included in any reports or publications.

CONSENT

I voluntarily agree to participate in this study

Participant Name: _____	Signature: _____
Date: _____	

Appendix II: Questionnaire

Section A: Demographic Information

study number/ID: _____

Age: _____years

Gender:

☐ Male

☐ Female

Highest level of education:

☐ No formal education

☐ Primary

☐ Secondary

☐ Tertiary

Other occupation: _____

How long have you been a cattle farmer?

☐ Less than 1 year

☐ 1–5 years

☐ More than 5 years

Number of cattle you own: _____

Location of the farm: _____

Duration of residence in this area

☐ 1year

☐ 2-5 years

☐ 6-10years

☐ more than 10years

Type of grazing:

☐ Nomadic

☐ Zero grazing

☐ Communal pasture grazing

Section B: Knowledge about Foot and Mouth Disease (FMD)

Have you heard of foot and mouth disease (FMD) (Kalusu) in cattle?

☐ Yes

☐ No

If yes where or whom did you hear it from (source of information about FMD)

☐ Friends

☐ Neighbors

☐ Animal health practitioners

☐ Media

Has your herd ever been affected with FMD?

☐ Yes

☐ No

What are the common signs of FMD in cattle? (Tick all that apply)

☐ Fever

☐ Blisters in mouth or feet

☐ Excessive salivation

☐ Lameness

☐ Reduced milk production

☐ Other (please specify): _____

How is FMD transmitted among cattle? (Tick all that apply)

☐ Direct contact with infected animals

☐ Contaminated equipment or feed

☐ Airborne transmission

☐ Other (please specify): _____

What other animal species were involved in the outbreak on your farm?

Can FMD be prevented by vaccination?

☐ Yes

☐ No

☐ Not sure

Section C: Attitude towards FMD Vaccination

How important do you think vaccinating your cattle against FMD is?

- ☐ Very important
- ☐ Somewhat important
- ☐ Not important

Do you believe vaccination effectively prevents FMD in your cattle?

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

What are your concerns, if any, about vaccinating your cattle against FMD? (Tick all that apply)

- ☐ Vaccine side effects
- ☐ Cost of vaccination
- ☐ Effectiveness of vaccine
- ☐ Accessibility of vaccines
- ☐ Other (please specify): _____

Section D: Practices Regarding FMD Vaccination

Have you ever vaccinated your cattle against FMD?

- ☐ Yes
- ☐ No

If yes, when did you vaccinate your cattle against FMD?

- ☐ Annually
- ☐ Every six months
- ☐ Only during outbreaks
- ☐ Other (please specify): _____

How affordable do you find the FMD vaccine?

- ☐ Very affordable

☐ Affordable

☐ Expensive

☐ Very expensive

How easy is it for you to access the FMD vaccination services in your area?

☐ Very easy

☐ Easy

☐ Difficult

☐ Very difficult

Who typically vaccinates your cattle against FMD?

☐ Veterinary officer

☐ Para-veterinarian / animal health worker

☐ Yourself (owner)

☐ Other (please specify) _____

How long do clinical signs of FMD typically take to heal in your animals?

☐ Less than 1 week

☐ 1-2 weeks

☐ More than 2 weeks

☐ Not sure

What kind of losses have you experienced due to FMD outbreaks? (Select all that apply)

☐ Decreased milk production

☐ Decreased meat production

☐ Loss of draft power (animal labor)

☐ Animal death

☐ Reduced market value

☐ Other (please specify) _____

Have you attended any training or workshop on Foot-and-Mouth Disease (FMD) vaccination or control?

☐ Yes

☐ No

If yes, how useful was the training/workshop in improving your knowledge and practices?

- ☐ Very useful
- ☐ Somewhat useful
- ☐ Not useful
- ☐ Did not attend

What sources of information do you rely on regarding FMD vaccination? (Tick all that apply)

- ☐ Veterinarians
- ☐ Fellow farmers
- ☐ Agricultural extension officers
- ☐ Media (radio, TV, newspapers)
- ☐ Other (please specify): _____

Who do you report to if you have FMD out breaks

- ☐ Area veterinary officer
- ☐ District veterinary officer
- ☐ Neighboring cattle farmer
- ☐ I don't report.

How quickly is vaccination usually administered following an outbreak or campaign?

- ☐ Within 1 week
- ☐ Within 2 weeks
- ☐ More than 2 weeks
- ☐ Not sure

What interventions do you use to prevent your herd from FMD

- ☐ Disinfect animal premises regularly
- ☐ Not buying cattle or other livestock from risky sources.
- ☐ Ask veterinarian to inspect animals before purchase

Other interventions you think is necessary to prevent or control FMD (Tick where appropriate)

- ☐ Early FMD detection by local veterinary workers

- ☐Regular visits by veterinary officers
- ☐Quarantine of new animals introduced to the herd/ in the village
- ☐Control of infected animal movements.
- ☐Isolation and treatment of sick animals
- ☐Subsidizing the cost of the vaccine
- ☐Don't know

Appendix III: Research pictorial evidence for data collection

