FARM-LEVEL PRACTICES AND COSTS OF DISEASE IN POULTRY FARMS WITHIN PERI-URBAN AREAS OF NAIROBI, KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university. The various journals and other sources referred for information have been duly acknowledged.

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DEDICATION

I dedicate this thesis to my father Pastor Richard Raphael Kimanzi, my mother Margaret Kalekye Ndunda, and my sons Emmanuel Mbatha and Gift Mwadime for their immeasurable support, guidance and sacrifice towards my education

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LIST OF ACRONYMS AND ABBREVIATIONS

AMR	Antimicrobial Resistance
AMU	Antimicrobial Use
ASAL	Arid and Semi-Arid Lands
CDVS	County Director of Veterinary Services
CRD	Chronic Respiratory Disease
DOC	Day Old Chicks
FAO	Food and Agricultural Organization
GARP	Global Antimicrobial Resistance Partnership
GPS	Global Positioning System
GVP	Gross Value of Production
HPAI	Highly Pathogenic Avian Influenza
IACG	Interagency Coordination Group
IBD	Infectious Bursal Disease
IEBC	Independent Electoral and Boundaries Commission
ILRI	International Livestock Research Institute
KNBS	Kenya National Bureau of Statistics
LMICs	Low and Middle Income Countries
NACOSTI	National Commission for Science, Technology and Innovation
NCD	Newcastle Disease
ODK	Online Data Kit

OR	Odds Ratio
USD	US Dollar
WHO	World Health Organization
WOAH	World Organization for Animal Health

ABSTRACT

Poultry farming in Kenya contributes to food security and improved livelihoods for many households and other value chain actors through the production of meat, eggs and other products such as cattle feed and manure. The occurrence of disease in poultry farms hampers productivity through increased mortality, reduction in growth rates and reduced egg production. Furthermore, indirect costs are incurred from treatment, vaccinations and implementation of farm biosecurity measures to control disease occurrences. This study investigated farm-level practices and costs of disease in poultry farms within the peri-urban areas of Nairobi. Data was collected from poultry farms on various production systems using structured questionnaires which were coded in an open data kit. The data obtained was analyzed using STATA version 17.0 statistical software and descriptive statistics measures computed. Most farmers (89%) implemented proper cleaning and washing of equipment, poultry houses and their environment. Respiratory syndromes and diarrhoea were the most common clinical signs observed in poultry farms. Most poultry farms were vaccinating against Newcastle disease (NCD) (75%) and infectious bursal disease (IBD) (63%). Forty-three percent of the farmers consulted a veterinarian and 70% of farmers treated sick birds using veterinary drugs while 36% used herbal remedies. Over 90% of the farmers used poultry litter as manure in crop farms while 10% either sold or gave it away. Economic costs of diseases in poultry farms were estimated through direct losses from mortality and indirect costs incurred from the use of antimicrobials, vaccinations and farm biosecurity management. Indigenous chicken and day-old chicks had the highest mortality rate of 17.6% and 15.2% respectively, while the mortality rate for improved indigenous chicken and layers was 13.8% and 12.2% and broilers had the lowest mortality rate of 7.9%. Direct losses from indigenous chicken were higher than in other poultry types at approximately Ksh. 141 per bird per production cycle (Exchange rate 1 USD= Ksh. 100). The direct losses per cycle from improved indigenous chicken, layers and broilers were Ksh. 138.3, 85.3 and Ksh. 29.3 per bird, respectively. Indirect costs from vaccination and treatment per bird were high for improved indigenous chicken at Ksh. 24.4 followed by layers (Ksh. 22.15) and low in broilers (Ksh. 7.95). On further analysis using logistic regression, there was reduced likelihood for self-treatment of sick birds by farmers for farms where sudden death of birds was reported (OR= 0.10) as well as farms where veterinarians were always consulted for treatment of sick birds (OR = 0.13). However, there was a higher likelihood for self-treatment of sick birds by farmers: Slaughter of sick birds that don't show progress on antimicrobial treatment (OR = 51.41), continuing with antimicrobial treatment even when birds don't show signs of improvement from the current treatment (OR = 49.86), having a fenced farm compound (OR = 6.55) and consulting a pharmacist on diagnosis of sick birds (OR = 11.83). The study has demonstrated a biosecurity knowledge gap among poultry farmers, it was evident that most poultry farmers do not seek professional help from veterinarians and Para veterinarians for the diagnosis and treatment of poultry diseases on their farms. Poultry farmers commonly practice self-treatment when their flocks have diseases. The lack of proper diagnosis could lead to misuse of antimicrobials and consequently emergence and spread of antimicrobial resistant pathogens. The direct cost due to mortality was very high compared to indirect cost associated with vaccination and treatment, and that farmers who often consulted veterinarians for diagnosis and treatment of sick birds had reduced odds of self-medication of their birds. This study has provided a baseline status on farm-level practices that are associated with the risk of disease spread and cost of disease in different poultry farms. It is recommended that awareness creation be enhanced on practicing preventive biosecurity measures such as restricting access to birds by visitors, vehicles and other livestock; cleaning and disinfection of farm equipment and poultry houses; proper disposal of dead birds and used litter. Additionally, farmers should be urged to seek the advice of animal health workers when birds are sick, and also keep records.

1 CHAPTER ONE: INTRODUCTION

1.0 Background

The global poultry industry is a fast-growing sector with an estimated annual production of over 90 billion tons of chicken meat (Agyare *et al.,* 2018). Many African nations' protein shortages are starting to be significantly reduced by the use of eggs and chicken meat (Attia *et al.,* 2022). However, it's been noted that in Africa rural and peri-urban regions account for about 80% of poultry production (Chingonikaya & Salehe, 2018). According to a published review, the continent of Africa recorded an increase in chicken meat production from 3,297 thousand tons in 2005 to 4,592 thousand tons in 2011 (Stino & Nassar, 2013). In Kenya, the poultry industry contributes approximately 20,000 metric tons of meat and 1,255 million eggs annually (FAO, 2015). The poultry population in Kenya is approximately 44.6 million (KNBS, 2019), with the bulk of the population (84%) comprising free-range indigenous chicken, followed by commercial layers (8%) and broilers (6%). Other species include ducks, turkeys, ostriches, pigeons, quails, and guinea fowls (2%) (Onono *et al.,* 2018). Noteworthy, the burden of infectious disease is highest within countries with poor sanitation and hygiene status, in addition to limited capacities for human health and veterinary systems (Afakye *et al.*, 2020).

Farm-level practices in poultry farms include monitoring the health of flocks, maintaining ideal conditions for brooding, rearing, growing, and laying, administering recommended immunizations and using the right feeding regimens (Vaarst *et al.,* 2015). Due to sub-optimal living conditions such as lack of high-quality feed, immunizations and qualified workers, as well as suboptimal housing conditions, it is frequently challenging to get birds to perform at their best in developing nations (Ravindran, 2013). Farmers often strive to make sure that feed for birds satisfies the nutritious needs of every age group and variety of hens. Small farms in underdeveloped nations often concentrate less attention on maximizing production and more on optimizing profitability by relying primarily on locally sourced feed ingredients rather than imported feeds (Mottet & Tempio, 2017). Farmers who mix their feed should follow certain management procedures, such as keeping micro-ingredients cool, avoiding the use of moldy ingredients and using weather- and rodent-proof storage facilities (Ravindran, 2013).

Farming practices that include violation of drug withdrawal periods, suboptimal treatments and non-adherence to instructions on drug usage are rampant within developing countries (Afakye *et al.,* 2020; Caudell *et al.,* 2017). Livestock farmers frequently use antimicrobials in the management of diseases without prescriptions or without seeking the opinion of animal health professionals, leading to over- and misuse of antimicrobial drugs, and driving the development of antimicrobial resistance (AMR) within the connected farms and systems (Mutua *et al.,* 2020). Antimicrobials that comprise; antibiotic, antifungal, antiparasitic and antiviral products are important for the treatment and prophylaxis of disease conditions that affect human, animal and plant health (Zhu *et al.,* 2022). Antimicrobials are frequently used in livestock production to cure infections, promote health, animal welfare and control the spread of infectious diseases (Graham *et al.,* 2019). In several parts of the world, they are also used to prevent diseases where they are likely to occur and to increase animal productivity (Gemeda *et al.,* 2020; Sneeringer *et al.,* 2015; Van Boeckel *et al.,* 2015). More than sixty percent of all produced antimicrobials are used in animals for both medicinal and non-therapeutic uses (Agyare *et al.,* 2018).

Birds must remain healthy to perform to their highest capacity but, diseases remain among the most significant barriers to the production of poultry (Ezra *et al.,* 2020). Diseases develop as a result of improper management and care, poor nutrition and various other causes (Habte *et al.,* 2019). Disease outbreaks remain the greatest cause of poultry mortalities (Ochieng *et al.,* 2013). Almost all animal species have a lifetime risk of contracting a variety of diseases. On poultry farms, establishing and implementing daily biosecurity protocols as best management practices will lessen the likelihood of introducing contagious diseases (Sharif & Ahmad, 2018).

By keeping the farm clean, using biosecurity precautions, and immunizing the poultry, infections can be prevented. Improved biosecurity at production facilities can be achieved through segregation of potential microorganism carriers (such as wild birds and rodents) from production facilities (Meirhaeghe *et al.,* 2019). Also, swift removal and proper disposal of dead animals, the use of chemical barriers to kill microbes through cleanliness & hygiene and the placement of chicken houses far from possible sources of infection such as large water bodies that attract wild birds are all recommended (Davies & Wales, 2019).

Vaccination is essential to keep birds free from preventable diseases (Sneeringer *et al.,* 2015). Additionally, farmers should optimize the feeding of their birds and prevent diseases in addition to selecting disease-resistant animals for breeding. In nations where most poultry are raised in small-scale and scavenging models, such as Vietnam, where more than 8 million families rear poultry, effective surveillance for illnesses is quite challenging (Hinrichs *et al.,* 2006). Reporting and confirmation of an outbreak is very important to determine disease status and develop control measures (WHO, 2020).

Threats from animal diseases pertain to the environment, the welfare of animals, human health and the economy. Direct economic losses on affected farms include increased mortality, reduced egg production, loss of weight, growth retardation, reproductive losses, premature culling and reduced slaughter value (Zachar. *et al.,* 2016). Indirect economic losses are incurred due to prevention and control costs such as improved biosecurity and management costs, vaccination, and treatment costs such as veterinary care, medications and additional farm labour (Mohammed & Sunday, 2015). Other costs are incurred in losses in traded poultry and their products, decreased market values, and food insecurity.

The economic impact and costs of risk reduction are unequally distributed among the various stakeholders, including consumers, poultry farmers and governments. Since disease control is acknowledged as a public benefit activity, some expenditures are covered by governments or foreign donors (Bertram *et al.,* 2018). For national and global policymakers to choose the most effective and economical control techniques, the complete long-term expense of each measure should be evaluated, regardless of the cost sharing and distributional consequences between the stakeholders (Tremetsberger & Winckler, 2015). To justify a disease control program or to calculate returns on animal health investments, the cost-benefit for a program needs to be analyzed. Data on production losses, the costs of intervention for common diseases and related risks are needed to inform resource prioritization and budget set aside to increase animal welfare and health (Rushton & Gilbert, 2016).

Poultry production in Kenya has significant setbacks due to problems including high feed costs and poor feed quality, diseases and parasite infestation, poor animal care and husbandry methods and predation (Ogada *et al.,* 2016). In the Kenyan context, there exist limited research reports that have documented farm-level practices and responses to occurrence of disease and the associated cost of interventions. This study was designed to investigate the farm-level practices and cost of disease in poultry farms within peri-urban areas of Nairobi, Kenya, case of Machakos and Kajiado counties in Kenya.

1.1 Problem statement

The research problem providing the basis for this study is inadequate knowledge of the association between farm-level practices, the occurrence of diseases and the costs of disease control in poultry farms in Kenya. The challenges to Kenyan poultry farmers are comparable to those affecting farmers within the low and middle income countries (LMICs) with similar production systems, healthcare infrastructure and regulatory environments (Van Boeckel *et al., 2015)*. The major factors promoting disease spread in poultry production are delayed observation, diagnosis of disease, access to quality veterinary advice and services when farmers require diagnoses and treatment of their livestock. Livestock farmers frequently rely on the advice of unqualified persons for diagnosis and treatment, but some would rely on their knowledge and previous farm experiences in the management of diseases (Caudell *et al.,* 2020; Kiambi *et al.,* 2021). These practices have been exacerbated by the privatization of animal health services in Kenya to curb the recurrent expenditure in government. While the majority of private veterinarians and para-veterinarians are found in high rainfall, intensive agricultural zones, this hasn't been the case in arid and semi-arid lands (ASAL) (Makau, 2012). Veterinary services privatization has led to the proliferation of shops that dispenses veterinary drugs to farmers and animal healthcare providers without following the laid down protocols (Atampugre, 2021). Most public veterinary services are frequently underfunded within the LMICs (Hobbs *et al.,* 2021). The capacity for veterinary laboratories and trained veterinarians are inadequate due to scarce government resources available in many of these countries. This study aims at increasing evidence of farmers' knowledge and farm practices that promotes disease spread and non-prudent use of drugs especially antimicrobials in poultry production in Kenya and their associated potential cost of disease.

1.2 Justification of the study

An increasing number of Kenyan farmers are adopting poultry farming either as a supplemental or main source of income with poultry farming contributing significantly to food security and livelihoods. There are many benefits associated with proper medication and antimicrobial use, conversely, there also exists a myriad of potential negative impacts due to antimicrobial resistance. Currently, there is limited knowledge on factors that drive livestock farmers to overly use antimicrobials vis-a-vis adopting and strengthening biosecurity measures in their production systems. Given these patterns and the lack of research on farm practices as drivers for increased use of medicines, it is vital to conduct this study to determine the influence of farm practices on the cost of diseases in similar poultry production systems.

1.3 Objectives

1.3.1 Overall objective

To investigate farm-level practices and costs of disease in poultry farms within peri-urban areas of Nairobi, Kenya.

1.3.2 Specific objectives

1. To determine farm-level practices that influence disease spread in poultry farms
2. To estimate direct and indirect costs of disease in poultry farms
3. To assess farm-level practices that are associated with self-treatment of sick birds by farmers

2 CHAPTER TWO: LITERATURE REVIEW

2.1 Farm-level practices in poultry farms

Infectious diseases in poultry can be prevented through good management practices and improved animal welfare thus enhancing poultry productivity and better immunity. To ensure that the safety and ecological demands of the birds are met, farmers make up for unfavorable climatic circumstances by changing the housing or managing control systems (Costantino *et al.*, 2021; Glatz & Pym, 2010).

Although most nations have efficient disease-prevention methods for chicken farms, adoption rates are frequently quite low (Lindahl *et al.,* 2019). The most crucial method for managing the majority of poultry diseases is vaccination of birds. Yet vaccination failure and ensuing outbreaks in immunized chicken remain significant problem in poultry production (Lindahl *et al.,* 2019). This may be caused by the use of live vaccines, which might turn virulent and cause disease. Moreover, live vaccinations may lose viability owing to improper handling and fail to produce the expected immunological response (Mutinda *et al.,* 2019). To reduce the danger of disease introduction and the associated economic impact, strict use of disease-prevention management strategies and hygienic procedures at the farm-level is essential (Frössling & Nöremark, 2016).

Just a small percentage of poultry producers are aware of and practice biosecurity measures, even though it is an essential instrument in the fight against the spread of infectious illnesses in poultry. The most crucial biosecurity concepts are still containment and isolation (Silva *et al.,* 2020). Effective sanitation and disinfection strategies can drastically lower infection rates by reducing microorganisms in the surroundings down to noninfectious levels (Das Gupta *et al.,* 2022). Taking breaks for cleaning and disinfecting helps to prevent the spread of sickness from older to younger birds (Sharif & Ahmad, 2018). Despite not always being economically feasible, sanitation measures lower infection rates of diseases by lowering pathogen concentrations in poultry houses. Equipment should be thoroughly cleaned and effluent water managed properly to prevent re-infection of cleaned premises.

Increasing demand for livestock products drives farmers to use antimicrobials to enhance growth and prevent diseases, which promote the prevalence of AMR (Cuong *et al.,* 2018; Gemeda *et al.,* 2020; Loo *et al.,* 2020). Farm practices such as repeated and uncontrolled usage of antimicrobials in feed proficiency enhancement, growth promotion and prophylaxis may hasten the occurrence of AMR in disease-causing pathogens, as well as in commensal micro-organisms (Lekshmi *et al.,* 2017). Resistant microorganism poses a great risk to humans, pets and other domesticated animals when in a contaminated environment or in direct contact. It has been argued that the health and economic benefits of antimicrobial use (AMU) are currently overshadowed by the threat of AMR (Ojo *et al.,* 2016; Parsonage *et al.,* 2017). AMU is a major factor in AMR. AMU is anticipated to rise significantly in the livestock industry by approximately sixty-seven percent by the year 2030 (Caudell *et al.,* 2020; Cuong *et al.,* 2018; Gemeda *et al.,* 2020; Kiambi *et al.,* 2021; Van Boeckel *et al.,* 2015; Van *et al.,* 2020). Limited development and production of new antibiotics in recent years and increasing loss of potency among existing antibiotics against important pathogens pose additional threats to AMR that require ideal farm practices in the management of diseases (Parsonage *et al.,* 2017).

2.2 Disease management and prevention strategies

Production of livestock constantly forces farmers to make judgments about disease impacts and choices on control measures. These management decisions can involve biosecurity measures in vulnerable flocks before disease development or involve control measures like vaccination (Sharif & Ahmad, 2018). Both farm practices and disease prevalence in inhabitants (livestock and persons) in the relevant area affect the likelihood of contracting a certain disease. The likelihood of infection rises as prevalence in the area rises. It is possible to lessen the risk of disease spread between farms by properly running and monitoring farms (Tanquilut *et al.,* 2020). Outbreaks of poultry diseases can be transmitted between farms and have a significant effect on the sector. Farm biosecurity regulations have become increasingly stringent, with necessary parameters outlined for commercial poultry farms (Hinrichs *et al.,* 2006). This involved taking precautions against wild birds, rodents, building disinfecting areas for footbaths and wheel baths among others.

Vaccination has been used to reduce infections in endemic areas and developed countries with a good surveillance system in place. Additionally, as a preventative measure, some European nations like France and the Netherlands would vaccinate some of their poultry flocks (Swayne & Sims, 2021). As long as the program is well implemented and uses vaccines of high quality and containing the relevant antigens, vaccination would lower the number of vulnerable poultry and the amount of virus that is circulating (Fentie *et al.,* 2014). Without immunization, H5N1 viruses from Vietnam would likely keep infecting more birds in waves and causing substantial high levels of death, particularly during milder months from November to March (Osterholm, 2017).

Antimicrobial drugs are used extensively in the majority of commercial livestock farming. Antimicrobials are crucial for maintaining a viable livestock industry and for preventing bacterial diseases in animals from spreading to people through the food supply (Ojo *et al.,* 2016). By reducing costs related to morbidity and death from bacterial illnesses, the use of antibiotics greatly improves productivity and increases profitability (Agyare *et al.,* 2018; Hao *et al.,* 2014; Sneeringer *et al.,* 2015; Teillant & Laxminarayan, 2015; Van *et al.,* 2020).

The emergence and dissemination of antimicrobial resistance (AMR) in disease-causing microorganisms are mostly attributed to exposure to antimicrobial agents. This development poses a serious risk to the therapeutic AMU's effectiveness in both human and animal medicine

(Ojo *et al.,* 2016). For cattle, hens and pigs, the global average yearly consumption of antimicrobials per kilogram of animal produced were estimated in 2015 to be 45 mg/kg, 148 mg/kg, and 172 mg/kg respectively. The amount of antimicrobials consumed globally is estimated to rise by sixty-seven percent between 2010 and 2030, from 63,151 ± 1,560 tons to 105,596 ± 3,605 tons (Van Boeckel *et al.,* 2015). Up to one-third of the increase in livestock antimicrobial intake between 2010 and 2030 is attributed to shifting production practices in middle-income nations where extensive farming systems would be replaced by intensive farming systems that regularly use antimicrobials in sub-therapeutic doses (Cuong *et al.,* 2018). The use and management of antimicrobials are still largely uncontrolled in African countries (Van *et al.,* 2020). Farmers would get the drugs from retail veterinary pharmacies and administer them to sick animals (Muthuma *et al.,* 2016). Tetracyclines, penicillin and sulphonamides are among the frequently administered veterinary products in food animals (Muloi *et al.,* 2019; Van *et al.,* 2020).

The three main factors driving AMU in livestock production are farm profitability, disease prevention and death rate reduction (Coyne *et al.,* 2019). The size of the livestock population, the intensity of the production system, the biosecurity measures on the farm and management practices are all believed to be directly connected to the amount of antimicrobials utilized (Ryan, 2019). During the past three decades, the need for antimicrobials has increased globally as a result of the substantial expansion in the market for animal products, which has pushed livestock farmers to switch to large intensive animal production systems (Van Boeckel *et al.,* 2015).

In the absence of effective disease prevention, highly integrated and intensive production systems need antimicrobials to make sure animal health, productivity and profitability are maintained (Chatterjee & Rajkumar, 2015). Resource-poor farmers keeping poultry on a small scale under scavenging and semi-scavenging production, practice ethnoveterinary medicine which is believed to reduce antimicrobial use. However, recent studies have noted a rise in the usage of antimicrobials in backyard, village and free-range poultry systems (Bamidele *et al.,* 2022).

Disease burden is high in Kenyan poultry farms with common diseases including Newcastle Disease, Gumboro Disease (Infectious Bursal Disease), Coccidiosis, necrotic enteritis, Sudden Death Syndrome/Acute Death Syndrome, Pulmonary Hypertension Syndrome and Ascites (Wong *et al.,* 2017). Antimicrobials are frequently overused to boost health and productivity as disease burden rises. There is a connection between the prevalence of resistance in people and animals, as well as between the prevalence of AMU at the population level in animals (Vieira *et al.,* 2011); (WHO, 2015). The primary cause of resistance is still careless AMU, and several studies have shown that LMICs have unrestricted access to antimicrobials through open marketplaces, mobile vendors, and unlicensed pharmacy outlets (Auta *et al.,* 2019; Bamidele *et al.,* 2022). In Kenya tetracycline, Penicillin, sulfonamides, trimethoprim, β-lactams, nitrofurans aminoglycosides and quinolones (in order of quantities) are the commonest drugs used in livestock (Mitema *et al.,* 2001). Antimicrobial drugs, such as classes of critically essential antimicrobial agents for human medicine like cephalosporins and fluoroquinolones are often used in animals for treatment and prevention (Ojo *et al.,* 2016). Poultry attracts the largest range of antimicrobials used (Boamah & Agyare, 2016; Mubito *et al.,* 2014; Muthuma *et al.,* 2016).

Antimicrobial usage in humans and livestock commonly overlap given that similar pathogens, and drugs that are commonly used in animals; penicillin, cephalosporin and tetracycline, can be used for humans (Loo *et al.,* 2020). In as much as there is increased access and proper use of antimicrobials in developing countries, data regarding actual antimicrobial usage (AMU) practices (quantity, mode, and reasons for use) are limited and this in turn limits trend monitoring with time, to measure liaisons between AMU and AMR (Klein *et al.,* 2018).

Access to such data assists in informed decision-making (WOAH, 2016; WHO, 2016). In most LMICs, there is poor enforcement of livestock AMU regulations with farmers having uncontrolled access to livestock medications, which may sometimes be counterfeit (Gemeda *et al.,* 2020) and not always supervised by animal health practitioners. At the moment livestock AMU information is scanty and drivers for livestock antimicrobial usage are barely understood yet this knowledge can assist in policy making.

Antibiotics, particularly those with broad-spectrum activity, are frequently used in small dosages in several African countries to aid in the management of endemic diseases among large farmed groups of mammals and birds as well as to promote the growth and feed efficiencies of food animals (Van *et al.,* 2020). About two hundred and fifty to three hundred million people in Africa depend on livestock for their livelihood and source of income, and livestock account for an average of 30% of the agricultural gross domestic product (GDP) and around 10% of the continent's overall GDP (de Haan, 2016). Other alternatives to antibiotic use in food animals include expanding the use of vaccines and probiotics. It is known that using probiotics, prebiotics or a symbiotic combination of the two can reduce pathogen colonization in an animal's intestines (Van *et al.,* 2020). Additionally, it has been suggested that food animals use phytogenic feed additives as antibiotic substitutes for antibiotic growth promotion in the suppression of potentially disease-causing microorganisms, thereby modulating the gut microbiota. These additives have been shown to improve intestinal health and gut performance (Van *et al.,* 2020).

2.3 Cost of disease management

In the past years, it has been estimated that diseases have impacted economies by more than $20 billion in direct costs and over $200 billion in indirect losses (Barratt *et al.,* 2019). Using data from the United States, the overall economic costs of sickness (including vaccinations) were around twenty percent of the gross value of production (GVP) and were roughly three times as costly as losses resulting from mortality (Biggs, 1982). The financial costs of poultry diseases in developing countries are not well understood (Bagust, 2013). This underlines the fact that indirect costs, which can often outweigh direct costs in terms of volume, are a crucial component of the economic impact of illness management. While direct disease costs are important, indirect disease costs are also a cause for worry since the costs of disease do not cease at the farm gate, inside the agricultural business, or when disease-freedom is declared (Espinosa *et al.*, 2020). Farmers are responsible for paying the costs associated with increasing farm biosecurity. This cost is unlikely to be incurred by the majority of villagers raising small flocks of poultry for commercial purposes, even if a simple expenditure of US$ 100 is necessary for disease control (Hinrichs *et al.,* 2006). This suggests that there is a necessity to persuade poultry caretakers to alter their practices and guarantee the production system's financial viability. Given the large numbers of smallholders in rural areas in LMICs, the costs of giving training may also be considered to be very significant (Kaminski *et al.,* 2020). Until the danger of infection decreases to a point where farmers can rely on biosecurity to prevent the entry of pathogenic microorganisms into their birds, vaccination against illnesses is important (Alarcón *et al.,* 2021).

In comparison to alternatives such as better management, biosecurity measures, changing quality and make-up of the feed and drinking water and vaccinations, antibiotics have been utilized more frequently because they are readily available and reasonably inexpensive when used to prevent a variety of bacterial animal infections (Ryan, 2019). The expenses of controlling and treating animals for a disease outbreak are anticipated to rise as the chance of resistance rises, which will raise production costs on livestock farms. To stop the growth of antimicrobial resistance, more focus should be put on alternative treatments in animal production and cost-benefit analyses of antimicrobials. The World Bank (2017) estimated the overall costs and benefits of antimicrobial resistance, noting that the possible benefits of containing AMR will differ between high- and middle-income countries, with the financial benefits ranging from 7 to 22 USD trillion if precautions are taken to reduce AMR by 50% (Roope *et al.,* 2019).

Due to lack of biosecurity and adequate immunization, backyard poultry in underdeveloped nations is mostly affected by two infectious illnesses, such as infectious bursal disease and Newcastle disease (Abdisa & Tagesu, 2017; Ezra *et al.,* 2020). Farmers are reluctant to disclose outbreaks which has led to low surveillance of infectious diseases in backyard poultry. Kenyan poultry farmers frequently depend on clinical signs for disease diagnosis due to inadequate laboratory facilities (Ezra *et al.,* 2020; Ogada *et al.,* 2016). Intensive poultry farming poses a serious risk to the management of illness but the provision of quality feeds to boost conversion ratios of poultry, using knowledge of poultry genetics in commercial breeding programs, and coordinated strategies, must be taken into consideration to improve poultry health (Kumar & Anil, 2020).

Due to a lack of biosecurity controls, backyard poultry may serve as a bigger source of highly pathogenic avian influenza (HPAI) infection than commercial birds. Additionally, in low and middle income countries (LMICs) like Pakistan, it is predicted that the daily average human interaction rate with private flocks was higher than with commercial poultry (5 contacts annually) (Samanta *et al.,* 2018). Chicken waste is fed to cattle and aquatic creatures and utilized as fertilizer in the soil, which promotes the spread of pathogens (Kyakuwaire *et al.,* 2019).

Due to the heterogeneous condition for diseases and infection, the introduction of improved chicken breeds into poultry production systems as an effort to boost the availability of food and income among rural families in Africa has highlighted the associated high mortality rate in the flock (Pius *et al.,* 2021). Instead of implementing more effective biosafety and biosecurity measures to lower the high disease load, poultry producers use antimicrobials to lessen this risk and boost the survival of the improved chickens (Hedman *et al.,* 2020). One factor contributing to smallholder poultry farmers' excessive use of antimicrobials is the lack of veterinarians and animal health workers in rural areas (Alhaji *et al.,* 2018). To promote growth, improve feed efficiency and prevent infections, animal producers frequently expose their animals to modest amounts of antimicrobials, which accelerates the development of resistance in commensal and pathogenic microbes alike (Agyare *et al.,* 2018; Van Boeckel *et al.,* 2015; Van *et al.,* 2020). This leads to unsuccessful treatments and financial losses and may spread the resistant genes to people (Gemeda *et al.,* 2020). Bacteria may spread across the farm, colonize other livestock and persist in the environment if they acquire resistance in food-producing animals. Newly acquired livestock is more likely to pick up organisms from the environment if the farm does not practice all-in-all-out management or effective hygiene for contaminated pens (Parsonage *et al.,* 2017).

2.4 Effect of Farm Practices on Medication of Poultry

Farmers rely on indigenous knowledge and practices in the majority of developing nations to control, prevent and treat the many illnesses that afflict both people and their animals (Sambo *et al.,* 2015). Notably, the majority of the farmers treat their chickens themselves with only a small proportion of them having access to or using veterinary services for diagnosis and medication of poultry. The lack of prescription for conventional as well as local medicinal herbs which are commonly administered through drinking water by the majority of farmers may also be considered self-medication. The use of herbs can be explained to some extent by the high prices of poultry drugs and the know-how of medicinal plants by the farmers. Previous studies have found the practice of self-medication to be rampant in many African countries for instance Kenya and Namibia (Masaire *et al.,* 2018). In research done in Kenya, only a small proportion of study farmers (12.5%) were reported to have sought veterinary advice when their birds were sick, with the remainder treating their birds on their own (Ezra *et al.,* 2020). Similarly, a study in Nigeria also reported that birds were mostly treated by 63.16% of farmers themselves (Adedeji *et al.,* 2014)

Self-medication and low use of veterinary services has been ascribed to both the lack of availability and high cost of veterinary services. For instance, in Kenya, the extension veterinary services are farmer demand driven and are poorly implemented (Hyelda *et al.,* 2021). Moreover, the shortage of veterinarians and animal health professionals in rural areas contributes to smallholder poultry farmers' usage of antimicrobials indiscriminately, which hastens the development of antimicrobial resistance in commensal and pathogenic organisms alike (Agyare *et al.,* 2018; Van Boeckel *et al.,* 2015; Van *et al.,* 2020). This results in treatment failures, economic losses and could lead to transmission to humans (Gemeda *et al.,* 2020). Bacteria may spread across the farm, colonize other livestock and persist in the environment if they acquire resistance in food-producing animals.

On the other hand, self-medication continues to thrive considering that poultry farming is commonly practiced on a small scale in minimally resourced settings, the availability of purported medicinal plants, easy preparation procedure of the medicine as well as administration (Sambo *et al.,* 2015; Silva *et al.,* 2020). Self-medication often results in poor management of diseases as reported in various studies (Mutinda *et al.,* 2019; Sambo *et al.,* 2015; Silva *et al.,* 2020). A study conducted in Nigeria identified farmers' knowledge, beliefs as well as gender as factors contributing to the self-medication of poultry. Programs on behavior change from self-medication were not impactful among poultry farmers (Paul *et al.,* 2012). According to a study done in Guatemala, independent of demographic variables, antibiotic self-medication was widespread in both rural and semi-urban people. Despite being less prevalent, using antibiotics on animals nearly always happened without veterinarian advice (Svenson *et al.,* 2021).

3 CHAPTER THREE: MATERIALS AND METHODS

3.1 Study area

The study was done in Kajiado North and Machakos Central Sub-counties in Kajiado and Machakos Counties respectively (Figure 1). The two counties border Nairobi County and are among the key suppliers of poultry meat that is consumed in the capital city of Nairobi. In each county, one sub-county was selected (considering the popularity of poultry production and proximity to Nairobi). Based on the recent population census report, Kajiado County had a total human population of approximately 1,117,840 people living in 316,179 households (KNBS, 2019) and has a total land area cover of 21,292.7 km^2. Kajiado County borders Nairobi and Tanzania to the south. It lies between Latitudes 10 0' and 30 0' South and Longitudes 360 5' and 370 5' East. Kajiado county comprises of five sub-counties namely Kajiado East, Kajiado North, Kajiado Central, Kajiado west, and Kajiado south with one hundred and one locations and two hundred and twelve sub-locations (KNBS, 2019)

The administrative headquarters of Machakos County is Machakos town. The county has a total land cover of 6,208 km^2 with a projected human population of 1,421,932 as of the 2019 population census report. Machakos county borders Embu county to the north, Nairobi and Kiambu counties to the west, Kitui to the east, Makueni to the south, Muranga and Kirinyaga to the northwest and Kajiado to the southwest. The county comprises of four sub-counties namely Machakos, Yatta, Kangundo and Mwala.

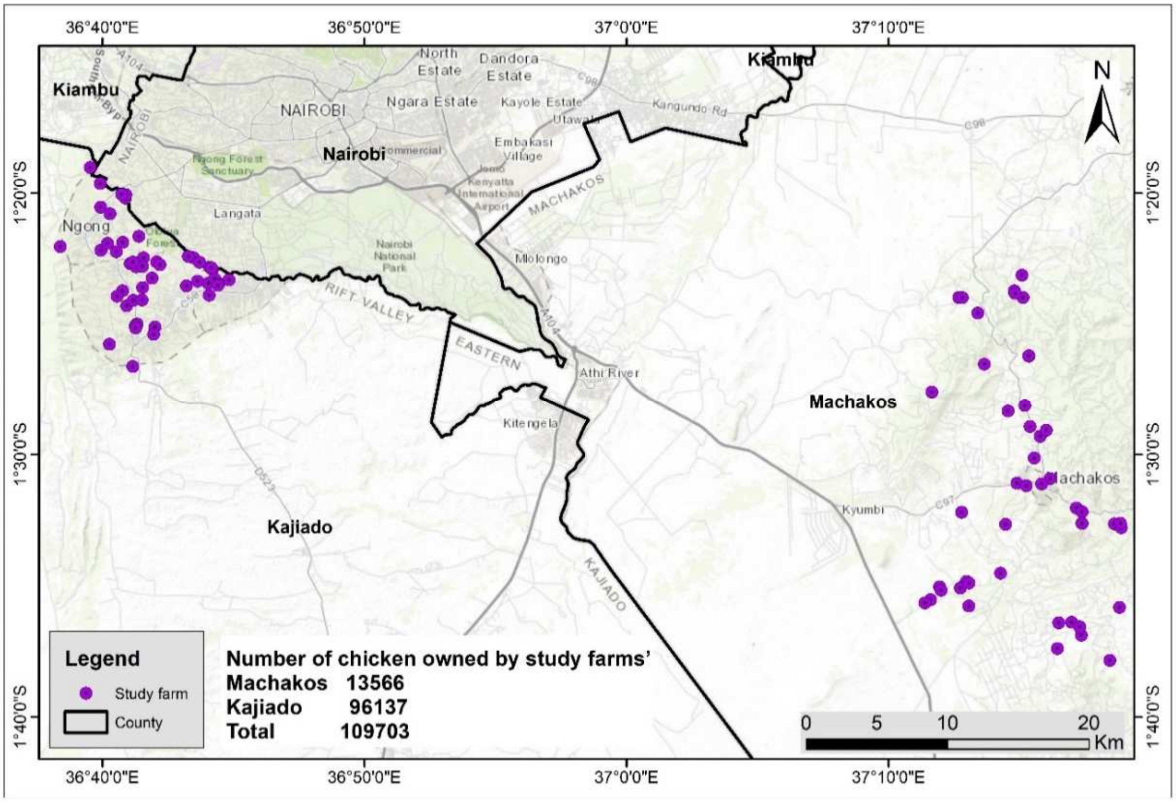

Figure 3-1 :Map showing areas of Kajiado North and Machakos central sub-counties where data were collected

3.2 Study design

The study employed a cross-sectional design to collect data on farm-level practices, farmer knowledge of antimicrobial use and costs of poultry disease management in farms. The choice of this study design was considered useful for gathering important data that can help to expand our understanding and insight on farm-level practices and the cost of disease in poultry farms within peri-urban areas of Nairobi. This was crucial for supporting the formulation of hypotheses for research to be conducted in the future using comparable production methods. (Kothari & Garg, 2014).

3.3 Study population

The target population comprised all poultry producers within peri-urban areas of Nairobi Kenya. This study included poultry keeping households that kept any of the poultry species in different production systems. Poultry farmers of both gender aged above eighteen years were recruited into the study with help from the local government livestock extension officers based on their willingness to participate in the study.

3.4 Sample size determination

To calculate an adequate sample size, the Cochran formula for determining sample size for estimating a proportion was used: $n = Z_{\alpha}^{2} pq / L^{2}$ (Singh & Masuku, 2014). Where n = sample size required; Z = standard normal deviate providing a confidence interval of 95% (1.96 was used); P = A prevalence of (50%) was used since there was no prior information on farm-level practices and costs of disease in poultry farms in Kenya; q = 1-p; and L = Allowable error (10%) n= (1.96^2 x 0.5 x 0.5)/0.1^2 = 96. A minimum sample size of 96 households was therefore calculated for the study.

3.5 Selection of study units

One sub-county was selected purposively from each county based on peri-urban setting, and further ten sub-locations were selected through simple random sampling technique to obtain a total of twenty sub-locations where households sampling was carried out. The poultry keeping households (sampling unit) in each sub-location were randomly selected using computer-assisted excel randomization sampling. A list of eligible poultry keeping households was generated from the office of the County Director of Veterinary Services (CDVS) in both Machakos and Kajiado Counties which formed the sampling frame for this study.

3.6 Data collection

Structured questionnaires were used to gather data from poultry farmers. Data that were collected included: demographic information of poultry farmers, farm characteristics, type of poultry farm, flock structure, health history and health status of the flock, practices of controlling poultry diseases including the use of vaccines, farm biosecurity practices, purposes and types of antimicrobials used and disinfectants and their average market prices. These questionnaires were formatted into an online data kit (ODK). Field data collection in both study sites was done using ODK collect software uploaded in tablets which were issued to field assistants. The global positioning system (GPS) coordinates were collected using an inbuilt GPS recorder in the ODK. During the field data collection, other methods were also applied including direct observation of production activities in the poultry farms and secondary data retrieval from published reports.

A pretest was carried out to evaluate the validity of the questionnaire before the commencement of the data collection exercise. The pretest was done in Kajiado County, ten poultry farms were visited, and farmers were interviewed. This exercise allowed for the reformatting of the questionnaire, to achieve the desired objectives of the study and estimate the amount of time which was required for completing each interview. The reliability of study tools was ascertained using the Cronbach alpha coefficient.

3.7 Data handling and analysis

The data collected by tablets using ODK collect was uploaded to a secure server and then downloaded from the server and presented in Microsoft Excel spreadsheets for cleaning. Data analysis was done using STATA version 17.0 statistical software and descriptive statistics measures were computed and results presented in tables. The mortality rate was calculated for each category of poultry: indigenous chicken, improved indigenous chicken, broilers, layers and day-old chicks. Further analysis involved computing proportion, Chi-square test of association and logistic regression to test for relationships between variables and antimicrobial usage in farms for self-treatment.

Farms were considered to practice self-treatment if they treated their animals' using antimicrobials without advice or prescription from an animal health worker. The self-treatment practice involved farmers purchasing antimicrobials from agrovets, applying herbal remedies for sick animals and consulting pharmacists on diagnosis and treatment. This was compared with the farms that only relied on consultation and treatment by qualified veterinary surgeons. Variables used in the analysis of farm-level practices included clean/disinfection, use of veterinary drugs (inclusive of vaccine), keeping birds well fed, use of special feed (inclusive of supplements), and fencing or avoiding birds from mixing with other flocks, source of help with diagnosis and treatment; and the ideal treatment of birds. The economic costs of disease in poultry farms were estimated using both direct (losses incurred through mortality) and indirect costs (cost of interventions from application of antibiotics used in treatment of sick animals, vaccinations and biosecurity management in farms).

3.8 Ethical Consideration

This study sought approval from National Commission for Science, Technology and Innovation (NACOSTI) license No: NACOSTI/P/20/8032, International Livestock Research Institute (ILRI) Ref No: ILRI-IREC2020-42. Respondents informed consent was sought before the interview began with an assurance of confidentiality by the researcher and the respondents were required to sign a consent form before the interview was done.

4 CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter describes the study findings analyzed from 100 households interviewed in peri-urban areas of Machakos county and Kajiado county. Study respondents were mainly (59%) female while most of the farm owners were men (79%). Most (57%) of the respondents were on average aged 50 years and above and had completed secondary school education (82%). In the majority (85%) of households, farmers relied on family members as a source of labor while 39% had hired one or two workers.

Most farmers kept different types of chicken on their farm during the previous production cycle that ranged from 13 to 34,000 in number. The types of chicken kept in farms included an average of 2,052 broilers ranging from 5 to 27,000 (18% households); an average of 506 layers ranging from 150 to 2,500 (24% households); an average of 182 improved indigenous chickens ranging from 15 to 1,500 (50% households); an average of 91 local indigenous breeds of chicken ranging from 10 to 400 (45% households); and an average of 2,119-day old chicks ranging from 68 to 8,000 (5% households). Other poultry kept included an average of 7 turkeys ranging from 1 to 40 in 16% of households; and an average of 10 ducks ranging from 1 to 36 in 17% of households. In addition to poultry, farmers also reared cattle (57%), pigs (10%), sheep (35%), goats (20%) and donkeys (5%). A proportion of these farmers (34%) did not keep any other livestock other than chicken. Noteworthy, all the broiler farms, majority of layer farms, 50% of improved indigenous chicken farmers, 45% of indigenous chicken and day old chick farms were purely for commercial purposes. Table 4-1 shows the result of poultry kept in Kajiado and Machakos counties during the previous production cycle.

Table 4-1: Poultry kept in the farms during the previous production cycle according to respondents in Kajiado and Machakos counties, Kenya

Poultry type	Machakos		Kajiado		Mean
	No. of farms	*Average*	*No. of farms*	*Average*	
Layers	8 (16%)	427	16 (32%)	585	506
Broilers	5 (10%)	1,380	13 (26%)	2,724	2052
Improved indigenous	31 (62%)	173	19 (38%)	191	182
Indigenous/ Local	21 (42%)	89	24 (48%)	92	91
Day old chicks	3 (6%)	203	2 (4%)	4,034	2119
Turkey	11 (22%)	8	5 (10%)	4	7
Ducks	9 (18%)	9	8 (16%)	11	10

4.2 Description of practices in poultry farms visited

Various practices which were reported by farmers, in addition to those that were observed by the research team were explained and summarized. Most farmers kept different types of poultry in addition to other types of livestock. See Appendix 5, Tables 7-2 and 7-17 for livestock kept and poultry housing practices respectively

4.2.1 Types of production systems practiced

All the broiler farmers and day-old chicks were kept indoors during the day and night periods. Most of the layer farmers housed their chickens. Fifty percent of farmers for improved indigenous chickens housed the birds during the day and night while 45% of indigenous chicken farms would be on free range during the day and put in a shelter at night. Most farmers

(87%) ensured proper feeding by ensuring appropriate quality and quantity of feed were available for chickens during the day. Farmers fed birds using commercial feeds (98%) with 50% supplementing with grain and/or crop residues and household waste; while 8% of the farmers formulated their feeds. Table 7-18 in appendix 5 shows type of feeds provided to poultry.

4.2.2 Farm biosecurity measures practiced

Most farmers reported that they ensured thorough cleaning and washing of poultry equipment and facilities (89%). Approximately 64% of farmers had fenced their compounds while 42% of farmers acquired inputs from licensed reputable sources including day old chicks (DOC). About 36% of farmers avoided mixing flocks of chicken from different batches while 27% used special feeds and supplements. Only 2% of farmers reported using protective clothing while attending to poultry. Table 7-5 in appendix 5 illustrates the disease prevention measures practiced

4.2.3 Post treatment handling of poultry products

Eggs collected during and a few days after treatment of birds were handled differently. In about 60 % of households, farmers consumed or sold the eggs to bakeries as they perceived that processing such eggs would destroy the antibiotics in the eggs. Only 16.49% of farmers threw the eggs away in the farm environment while 8.73% boiled them and fed them to dogs and 10.01% of farmers incubated the eggs to hatch for flock replacement. In case of no improvement after treatment, 68% of farmers changed the antimicrobials until the birds healed or died, 13% of farmers slaughtered the birds while 8% of the farmers culled and either sold or consumed them. In 5% of the households, farmers isolated the sick bird and sought a second opinion from a veterinarian. In 36% of farms, sick birds were slaughtered and either disposed of in an open environment, consumed or sold, or fed to dogs or pigs. The carcasses of birds that died during the last production cycle were disposed of from the farms safely by either burning or burying (48%); feeding to dogs (36%) and disposed of in open farm environments (21%). A small proportion of (4%) farmers consumed the carcass of dead birds. Table 7-11, 7-12, 7-13 and 7-14 show the different ways chicken products were handled.

4.2.4 Handling of used litter material from poultry houses

Approximately 91% of farmers used the collected litter materials from poultry houses as manure in their crop farms while the remainder of 9% of farmers often sold or gave it away, and 7% of the farmers also reported that they would feed their dairy cows with litter that was collected from their farms. Table 7-15 provides a summary on how litter was handled from the farms visited.

4.2.5 Farm-level disease management

Farmers in Kajiado and Machakos counties practiced different methods for control and prevention of diseases as shown in table 4-2

4.2.5.1 Disease prevention measures

Most farmers used veterinary drugs including vaccines (85%). On average, 81% of farmers vaccinated their birds against at least one poultry disease. Other veterinary products used by the poultry farmers for therapeutic and disease prevention purposes were antibiotics (69%), vitamins (76%), dewormers (57%), disinfectants (52%), acaricides (30%) and herbal products (medicinal plants) (28%).

Table 4-2: A summary of farmers who were treating and vaccinating poultry against common diseases

Product used for therapeutic and disease prevention	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Vaccine			
Newcastle (NCD)	41 (82%)	34 (68%)	75%
Infectious bursal disease (IBD)	31 (62%)	32 (64%)	63%
Fowl Typhoid	14 (28%)	19 (38%)	33%
Fowl pox	11 (22%)	13 (26%)	24%
At least one vaccine	42 (84%)	39 (78%)	81%
Medicines			
Antibiotics	38 (76%)	31 (62%)	69%
Vitamins	35 (70%)	42 (84%)	77%
Dewormers	20 (40%)	37 (74%)	57%
Disinfectant	18 (36%)	34 (68%)	52%
Acaricides	12 (24%)	18 (36%)	30%
Medicinal plants	7 (14%)	7 (14%)	14%

4.2.5.2 Description of common poultry disease symptoms in farms

Farmers recalled having observed respiratory syndrome (31%); diarrhea in poultry (26%); eye infection (15%); skin infection (8%); and neurological signs (8%) as clinical signs of diseases in farms. About 8% of farmers reported observing sudden death while 19% of farmers observed water belly, huddling, sick bird syndrome, dropping head, inactive, not eating, drooping wings and cannibalism. Most flocks of birds had shown clinical signs in the last month (51%); 1-6 months ago (31%); 7 - 12 months (7%); > 12 months ago (6%) while 5% have never seen sick birds in their farms.

Table 4-3: Common clinical signs observed by farmers

Clinical sign	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Respiratory syndrome	18 (36%)	13 (26%)	31%
Diarrhea	11 (22%)	15 (30%)	26%
Sudden death	3 (6%)	5 (10%)	8%
Skin diseases	5 (10%)	3 (6%)	8%
Neurological signs	2 (4%)	6 (12%)	8%
Eye infection	8 (16%)	7 (14%)	15%
Other conditions	6 (12%)	13 (26%)	19%

4.2.5.3 Description of who is consulted for diagnosis of poultry diseases

Approximately 48% of poultry farmers consulted agrovets (shops selling agricultural inputs) for diagnosis and treatment of sick birds while 32% consulted a private veterinarian and 4% consulted a public veterinarian. Nine percent of the farmers consulted either a friend, feed supplier or community animal health worker. A section of 31% of farmers kept records of the treatments administered to the birds or flocks that were sick.

Table 4-4: A summary of people who were consulted by farmers for diagnosis of poultry diseases

The person consulted for diagnosis	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Private Veterinarian	8 (16%)	24 (48%)	32%
Government veterinarian	4 (8%)	4 (8%)	8%
Pharmacist/ Agrovet person	35 (70%)	13 (26%)	48%
Other animal health provider	2 (4%)	1 (2%)	3%
Diagnosis by farmer	17 (34%)	14 (28%)	31%
Consult friend	3 (6%)	1 (2%)	3%
Feed supplier	1 (2%)	1 (2%)	2%

4.2.5.4 Disease diagnosis at the farm-level

An investigation on diseases that birds had been 'diagnosed' with was conducted without verification of whether the diagnosis was derived from laboratory results, a qualified animal health professional, attendants at veterinary pharmaceutical retail shops, or a farmer diagnosis. The frequent diseases/ symptoms which were reported by farmers were respiratory diseases (27%), coccidiosis (15%), infectious coryza (11%), Newcastle disease (6%), ascites (3%) and sick bird syndrome (10%). Other diseases/conditions observed were *Escherichia coli* infection, torticollis, diarrhea, sudden death, cannibalism, fleas and worm infestation (21%).

Table 4-5: A summary of diseases/symptoms that were reported by farmers to be prevalent in their poultry farms

Reported diseases	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Respiratory diseases	16 (32%)	11 (22%)	27%
Coccidiosis	6 (12%)	9 (18%)	15%
Infectious coryza	8 (16%)	3 (6%)	11%
Newcastle diseases	3 (6%)	3 (6%)	6%
Ascites	1 (2%)	2 (4%)	3%
Sick bird syndrome	6 (12%)	4 (8%)	10%
other diseases/conditions	8 (16%)	13 (26%)	21%

4.2.5.5 Consultation for treatment of diseases

Approximately 70% of farmers were self-medicating sick chickens using veterinary drugs. About 36% of farmers used medicinal plants to treat sick birds. Only 29% and 14% of farmers engaged private and public veterinarians to treat their birds. Six percent of farmers used feed suppliers or the person where chicks were sourced to medicate the birds or took the birds for laboratory diagnosis.

Table 4-6: Summary of veterinary service providers in studied poultry farms

Person providing medication	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Medication by farmer	39 (78%)	31 (62%)	70 (70%)
Private Veterinarian	11 (22%)	18 (36%)	29 (29%)
Government veterinarian	7 (14%)	7 (14%)	14 (14%)
Using herbal remedies	18 (36%)	18 (36%)	36 (36%)
Chick or Feed supplier	1 (1%)	4 (8%)	5 (5%)

4.3 Estimation of cost of disease in the study poultry farms

4.3.1 Determination of direct costs of production

Direct costs as a result of the mortality of chickens in farms were the main source of loss in poultry farms. Direct costs were calculated by multiplying the mean mortality of each type of bird with the current market prices as shown in Table 7 below. The mortality rate was calculated by dividing the mean of the number of birds that died during the last production cycle by the mean of birds at the start of the production cycle. Local indigenous birds had the highest mortality rate of 17.6% and broilers had the least mortality rate of 7.9%.

The direct cost from mortality per bird for local indigenous and improved indigenous was high at Ksh. 141 and Ksh. 138.3 per production cycle per bird respectively. Layers, broilers and day-old chicks had direct costs from mortality estimated at Ksh. 85.3, Ksh. 29.3 and Ksh. 15.2 per bird.

Table 4-7: Estimated cost of mortality per bird for different types of poultry

Type of Bird	Mortality (%)	Market Price of Chicken	Direct cost per bird
Improved Indigenous	13.8	1000	138.3
Indigenous	17.6	800	141.0
Layers	12.2	700	85.3
Broilers	7.9	370	29.3
Day old chicks	15.2	100	15.2

4.3.2 Determination of indirect costs of production in poultry farms

Indirect costs were computed based on average costs incurred per bird for vaccinations against diseases and treatments using antimicrobial agents. Improved indigenous chicken, layers and local indigenous chicken had a higher indirect cost per bird estimated at Ksh. 24.45, Ksh. 22.15 and Ksh. 22.11 respectively. Broilers had an estimated cost of Ksh. 7.95 per bird while the day-old chicks had an estimated indirect cost of Ksh. 12.59.

Table 4-8: Estimated cost for treatment and vaccination per bird in poultry farms

Type of Chicken	Cost in Ksh.
Layers	22.15
Broilers	7.95
Improved indigenous chicken	24.45
Local indigenous chicken	22.11
Day old chicks	12.59

4.4 Multivariate association model of Farm-level practices on medication by farmer

The variable medication by farmers was considered as the outcome measure for modeling due to its importance as a key pointer to antimicrobial usage in farms. There were 78% and 62% of farmers self-medicating poultry in Machakos and Kajiado respectively. For this analysis, self-medication included the use of both conventional drugs and traditional herbal remedies when chickens were reported as sick without the involvement of a veterinary professional.

4.4.1 Farm-level practices associated with self-medication

Farms, where sudden death of birds was often reported, had reduced odds (OR=0.10) for self-medication by farmers, as well as those farms consulting either private or public veterinarians for treatment of sick birds (OR = 0.13) (Table 9). However, a higher likelihood of self-medication was associated with farms that often-slaughtered sick birds that didn't show progress on treatment (OR = 51.41), farms that would continue with antimicrobial treatment even when the birds don't show signs of improvement (OR=49.86), farms with fenced compounds (OR=6.55) and farms that were consulting pharmacists on the diagnosis of sick birds (OR = 11.83).

Table 4-9: Farm-level practices that are associated with self-medication by farmers

Description of variables	Coefficient	SE	Z	Sig.	OR
Farms with fenced farm compounds	1.88	0.71	2.65	0.008	6.55
Sudden death of birds on farms	-2.32	1.03	-2.26	0.024	0.10
Consulting veterinarian for treatment	-2.06	0.68	-3.02	0.003	0.13
Consulting pharmacist on diagnosis	2.47	0.80	3.10	0.002	11.83
Slaughtering or selling birds that don't improve after treatment	3.94	1.40	2.82	0.005	51.41
Continue with treatment if chickens do not improve	3.91	1.30	3.02	0.003	49.86
Intercept	-3.31	1.30	-2.54	0.011	0.037

5 CHAPTER FIVE: DISCUSSION, CONCLUSION, AND RECOMMENDATION

5.1 Discussion

In this study, 89% of the farmers ensured thorough cleaning and washing of poultry equipment and facilities. In a survey carried out in Kenya to evaluate the knowledge, attitudes and practices on antimicrobial use among commercial poultry farmers in Kiambu, it was reported that farmers were cleaning drinkers (11%) and feeders (72%) at the end of the production process while 12% of the farmers claimed they never cleaned the feeders and foot baths at all (Kiambi *et al.,* 2021). West Bengal, backyard farmers showed low levels of biosecurity awareness, including preparing feed with untreated water (97%), cleaning feeding utensils and the drinking trough once a month (90%), and changing the drinking water in the trough every 15 days (90%) (Samanta *et al.,* 2018).

Most farmers (64%) had fenced their compounds while 42% of farmers acquired inputs from licensed reputable sources including day old chicks (DOC). About 36% of farmers avoided mixing flocks of chicken while 27% used special feeds and supplements. The farmers had fenced their compound to provide security and protect the family but had no association with provision of biosecurity to the chicken nor farmers self medicating their poultry as fencing increased the odds of self treatment.

In this study, only 2% of farmers reported using protective clothing while attending to poultry. In a different study in Kenya and Ghana on the impacts of animal health service providers on antimicrobial use attitudes and practices: an examination of poultry layer farmers , most homes reported owning various personal protection equipment (PPE), including gumboots, overalls, gloves and masks which were used across different layer houses and poorly cleaned posing a threat to disease transmission (Afakye et al., 2020). This is supported by a study done in layer farms in Kiambu on understanding antimicrobial use contexts in the poultry sector: challenges for small-scale layer farms where most farmers believed that PPE was mainly worn “to protect them from getting dirty” when completing their multiple daily chores, such as working in the fields and tending to the animals. As such, PPE was to protect oneself and not necessarily to prevent the spread of disease (Kiambi et al., 2021). Farmers perception of biosecurity measures is an optional advantage beyond the fundamental necessities of feed and drugs, rather than as necessities themselves. This finding is supported by another study in which farmers regarded the cost of AMU as the more affordable option compared to other disease management practices. This suggests that discussions of risks versus benefits in the context of costs and different possible outcomes may help to shift this perspective, particularly if paired with incentives such as subsidized biosecurity supplies (Kiambi et al., 2021)

Eggs collected during and a few days after treatment of birds were either consumed by humans or dogs, disposed of to the environment or incubated to hatch for flock replacement. According to a study done in Ghana on antimicrobial drug usage and poultry production, the vast majority of farms (92.9%) that were selling eggs while the laying hens were receiving treatment, had evidence of remnants of antibiotics that could be found in the eggs (Johnson *et al.,* 2019).

Change of antibiotics until birds healed or died was a common practice among majority of farmers. In few cases, farmers isolated the sick birds and sought a second opinion from veterinarian. Hygiene practice as an approach to managing infection and spread of diseases is often overlooked in consumption or poor disposal of dead birds. Safe disposal practices identified in the last production cycle included either burning or burying dead birds (48%). Notably, in 36% of cases, sick birds were slaughtered and either disposed of in an open environment, consumed or sold, or fed to dogs. Similarly, in a study on human exposure to antimicrobial resistance from poultry production: assessing hygiene and waste-disposal practices in Bangladesh, poultry carcasses were commonly disposed beside the poultry sheds where dogs or foxes usually scavenged for food (Alam *et al.,* 2019) . After the killing, the offals and viscera were tossed into the nearby shrubs and river. In a Southeast Asian study, it was found that nearly all Vietnamese and more than half of Thai people killed the birds at home on their own which heightened chances of transmission of infectious diseases (Das Gupta *et al.,* 2022).

According to a study on human exposure to antimicrobial resistance from poultry production: assessing hygiene and waste-disposal practices , the majority of the sick birds in Bangladesh were slaughtered for consumption or sold at the local market or to neighbors (Alam *et al.,* 2019). Drug residuals in sick birds often pose a public health risk to consumers and other organisms. In Ghana, tetracycline residue has been found in the majority (68%) of agricultural goods that were sold in broilers aged between 7 and 8 weeks old. The disposal of dead birds is often associated with some cost. According to research on framework for estimating indirect costs in animal health using time series analysis conducted in the UK, farmers were compensated £1.4 billion for the cost of animal disposal after the FMD outbreak in 2001 and the cost of animal slaughter and clean-up (Barratt *et al.,* 2019).

Notably, contamination of poultry products happens through the use of antimicrobials on the farm without respecting withdrawal periods, which may contribute to AMR among humans who consume these products (Silva *et al.,* 2020). Antimicrobial resistance is a rising global health concern, and it is predicted by the Interagency Coordination Group (IACG) On Antimicrobial Resistance, (IACG, 2019) that it will cause ten million deaths by 2050, if not addressed urgently. Other studies have shown that antimicrobial use in the world is likely to increase by 67% by 2030, which will also increase the likelihood of antimicrobial resistance significantly (Van Boeckel *et al.,* 2015). It is believed that the effort of all stakeholders in the livestock production value chain is required to prevent and reduce the risk of AMR in farms, especially those farmers who are considered the end users of antimicrobials (Mdegela *et al.,* 2021). This change can be achieved through increased dissemination of appropriate knowledge on antimicrobial use and the right attitude towards the use of antimicrobials by farmers. Majority of farmers used the collected litter materials from poultry houses as manure in their farms while a few farmers sold or gave it away or fed the collected litter to cows. Similar to in Bangladesh, the detritus, including the dried bird droppings, was collected in a basket and utilized right away as fertilizer (Samanta *et al.,* 2018).

The frequent diseases reported by farmers were respiratory diseases (27%), coccidiosis (15%), E coli infection (21%), infectious coryza (11%) and Newcastle disease (6%). A different study conducted in Kenya on small scale layer farms reported coccidiosis (64%) and CRD (63%) as the most frequently reported diseases (Kiambi *et al.,* 2021). Though there is a difference in disease burden in the two counties due to the types of poultry kept by farmers interviewed but it is evident that, coccidiosis and respiratory diseases were common. This study averaged disease status for all poultry types unlike the other one done on commercial layer farms.

Most farmers used veterinary drugs including vaccines. On average, majority (81%) of the farmers vaccinated their birds against at least one disease. Other veterinary products used by majority of the poultry farmers for therapeutic and disease prevention were antibiotics, vitamins, dewormers, and disinfectants. Fewer farmers used acaricides and herbal products (medicinal plants). In a different study conducted in Kenya, farmers self-reported having vaccinated against Newcastle disease (100%), Gumboro (100%), Fowl Pox and Fowl Typhoid (both 95%), Newcastle combined with Gumboro (95%), while just a handful claimed having vaccinated against Marek's Disease (4%) (Kiambi *et al.,* 2021). Research by the Global Antimicrobial Resistance Partnership (GARP) Kenya further recommends that vaccination is key in slowing down resistance rates, preventing infections, and promoting general public health, when accompanied by proper use of antibiotics to treat only curable bacterial infections, rather than fungal, viral, and parasitic diseases (GARP, 2011).

Most farmers were self-medicating sick chickens using veterinary drugs. About 36% of farmers used medicinal plants to treat sick birds. Unprescribed conventional as well as local medicinal herbs are commonly administered through drinking water by majority of farmers. Previous studies have found the practice of self-medication rampant in many African countries for instance Kenya and Namibia (Masaire *et al.,* 2018). Similar to this study, most developing countries have reported that farmers rely on local wisdom and methods to manage, stop, and treat the many illnesses that afflict both people and their livestock (Sambo *et al.,* 2015). Notably, the majority of the farmers treat their chickens themselves with only a small proportion of them having access to or using veterinary services for diagnosis and medication of poultry. A study in Nigeria indicated that birds were mostly treated by 63.16% of farmers themselves (Adedeji *et al.,* 2014). Self-medication and low use of veterinary services has been attributed to the unavailability as well as the high cost of veterinary services. For instance, in Kenya and Nigeria, veterinary extension services are farmer demand driven and are poorly implemented (Hyelda *et al.,* 2021). Self-medication continues to thrive considering that poultry farming is commonly practiced on small scale in minimally resourced settings, the availability of purported medicinal plants, easy preparation procedure of the medicine as well as administration (Sambo *et al.,* 2015; Silva *et al.,* 2020).

Self-medication often results in poor management of diseases as reported in various studies (Mutinda *et al.,* 2019; Silva *et al.,* 2020). A study conducted in Nigeria identified farmers' knowledge, beliefs as well as gender as factors contributing to self-medication of poultry, unlike this study. Programs on behaviour change from self-medication were not impactful among poultry farmers (Paul *et al*., 2012). A study conducted in Guatemala opined that regardless of demographics, antibiotic self-medication was widespread in both semi-urban and rural groups. Despite being less prevalent, using antibiotics on animals nearly always happened without a veterinarian consultation. (Svenson *et al.,* 2021).

Frequently, 48% of farmers consulted agrovets for diagnosis and treatment while 32% consulted a private veterinarian and 8% consulted a public veterinarian. About 29% and 14% of farmers used private and public veterinarians to treat their birds. Nine percent of the farmers consulted either a friend, feed supplier or community animal health worker. Six percent of farmers used feed suppliers or the person where chicks were sourced to medicate the birds or took the birds for laboratory diagnosis. It is an acceptable farming practice as observed in industrialized nations like the United States, the United Kingdom, and Chile to use veterinarian services (Samanta *et al.,* 2018). In Ghana, only 12.1% of farmers asked their veterinarian for a personal prescription before buying medications for the birds (Johnson *et al.,* 2019). Similar to these studies, farmers' reluctance to seek the recommended veterinary care has been observed even in developed nations (Samanta *et al.,* 2018). These practices were attributed to poultry farmers' experience in identifying and addressing disease challenges in the farms over the years. Also, according to research that was done in Bangladesh, most farmers often trusted their feed suppliers in matters of disease control, prevention, and treatment (Hassan *et al.,* 2021).In a study conducted in Kenya, a small proportion (12.5%) of study farmers had consulted a veterinarian when the birds were sick while the rest treated their birds without veterinary input (Ezra *et al.,* 2020). Lack of veterinarians and animal health practitioners in rural communities is one factor contributing to predisposing smallholder poultry farmers to uncontrolled use of antimicrobials leading to acceleration of the development of resistance by pathogens as well as in commensal organisms to survive (Agyare *et al.,* 2018; Van Boeckel *et al.,* 2015; Van *et al.,* 2020). This results in treatment failures, economic losses and could lead to transmission of resistant bacteria to humans (Gemeda *et al.,* 2020).

The main (75%) source of loss in poultry farms in this study was direct costs as a result of mortality of chickens in farms. Improved indigenous chicken and day-old chicks had the highest mortality rate in this study. A different study conducted in Kenya indicated that the median fatality across a typical production cycle was 50 birds, with a first quartile of 25 birds and a third quartile of 100 birds (Kiambi *et al.,* 2021). In this study, broiler chicken farms had lower costs from mortalities compared to other production systems. Layer farms also had high levels of indirect costs associated with vaccinations of birds against diseases and treatments using antibiotics. The direct cost per bird of local indigenous and improved indigenous chicken was the highest at approximately Ksh. 141 and Ksh. 138.3 per cycle. Layers had direct costs of Ksh. 85.3 and broilers had a direct cost of Ksh. 29.3. Day old chicks had direct costs of Ksh. 15.2. Indirect costs were computed based on costs incurred per bird in vaccinations of birds against diseases and treatments using antimicrobials. Direct costs that warrant compensation are often experienced especially in disease outbreaks. For instance, the first HPAI outbreaks in Nigeria wiped out around 440,000 birds which called for the Nigerian government to declare a compensation rate of US$1.95 per bird (Hinrichs *et al.,* 2006).

Improved indigenous, layers and indigenous chicken had a higher indirect cost per bird of Ksh. 24.45, Ksh. 22.15 and Ksh. 22.11 respectively compared with broilers that had a cost of Ksh. 7.95. Day old chicks had indirect costs of Ksh. 12.59. According to research done on a broiler farm in Finland, the average cost of biosecurity is 3.55 euros (or $0.04 in US dollars) per chick (Siekkinen *et al.,* 2012). Also, research done on backyard farms in rural areas of poor nations found that biosecurity measures are rarely used because of a lack of understanding and the expensive cost of the procedures (Fagrach *et al.,* 2023). For example, the cost of a hen house in Cambodia is US$ 25, whereas, the average monthly income of a Cambodian family is US$ 75 (Hinrichs *et al.,* 2006).

Indirect costs vary regionally based on a couple of factors. For instance, research done in Vietnam stated that the cost of administering a dose of vaccine to a chicken in Vietnam is estimated at US 3.8 cents presuming vaccine expenses of 1.6 cents, a vaccinator team wage of 1.3 cents, and additional costs associated with vaccine delivery of 0.9 cents (Hinrichs *et al.,* 2006). The Vietnam case is different from the African context where import costs add to the vaccine cost. Additionally, locations with lower concentrations of poultry population and a scarcity of qualified animal health providers are faced with a higher cost of implementing farm practices such as biosecurity mainly due to higher transportation costs. In a study carried out in Hong Kong, the cost of enhancing biosecurity measures during HPAI outbreaks differed from farm to farm (Dorea *et al.,* 2010). The percentage of indirect to direct expenses may be influenced by how direct and indirect costs are defined. In this study, direct costs formed 75% of the total costs. This was different from other studies where indirect costs made up about 4–9%, 79%, 97% and 29% of overall costs (Barratt *et al.,* 2019).

Indeed, previous reports have shown that keeping farm records is instrumental in promoting timely and proper administration of vaccines and medication while avoiding abuse and overuse of antimicrobials (Pinto Ferreira *et al.,* 2022). However, in this current study, only 31% of farmers kept records of the treatments administered to the birds. In Ghana, majority of farmers kept records of their production activities, and only 8.8% of them kept records of their prescription use (Johnson *et al.,* 2019). Commercial poultry producers must keep records that show the duration of administration, dosage and method of administration. This comprehensive record keeping plays a critical role in monitoring and reviewing the impact and effectiveness of antimicrobial use (Imam *et al.,* 2020).

5.2 Conclusion

- The study has demonstrated a biosecurity knowledge gap among poultry farmers. Some farmers did not isolate sick birds; they mixed multiple bird types; practiced poor disposal of carcasses and minimum use of protective gear.
- From this study, it was evident that most poultry farmers do not seek professional help from veterinarians for the diagnosis and treatment of poultry diseases on their farms. Poultry farmers commonly practice self-treatment when their flocks have diseases and commonly consult non-veterinary professionals for their diagnosis. The lack of proper diagnosis could lead to misuse of antimicrobials and consequently emergence and spread of antimicrobial resistant pathogens.

- Most of the farmers were not keeping records for production, diseases and important activities within the farm. Farm records are an important tool for decision making by farmers and veterinarians for determining profitability of various techniques used at the farm, keeping memory on what was done, comparing the efficiency of inputs used for example when implementing a new / alternative systems like vaccination and putting biosecurity measure and also helps the farmer in improving the efficiency of farm operations. This could potentially lead to misuse of antimicrobials, because of missing information on disease events and previous treatments.

- Generally, the direct cost due to mortality was very high compared to indirect cost associated with vaccination and treatment.

Regression analysis proved that farms that often consult veterinarians for diagnosis and treatment of sick birds had reduced incidences of self-medication by farmers.

5.3 Recommendations

a) This study recommends that farmers should invest more in preventive biosecurity measures at the farm-level.

b) There is a need to sensitize farmers on seeking professional services and proper handling of poultry to avoid contaminating the birds as well as the farm environments.

c) Farmers' access to veterinary professionals must be enhanced.

d) Importantly, farmers need also to be aware of the importance of record keeping and incorporate it into their routine farm management.

5.4 Limitations

The study did not assess the biosecurity measures employed in the production of day-old chicks. Notably, sharing uninspected incubators without proper biosecurity measures may lead to spread of diseases in farms.

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6 APPENDICES

Appendix 1: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR
SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **959284**

Date of Issue: **21/December/2020**

RESEARCH LICENSE

This is to Certify that Dr.. Florence Kanini Mutua of International Livestock Research Institute, has been licensed to conduct research in Kajiado, Machakos on the topic: Management of animal diseases and antimicrobial use by information and communication technology to control AMR in East Africa for the period ending : 21/December/2021.

License No: **NACOSTI/P/20/8032**

959284

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR
SCIENCE,TECHNOLOGY &
INNOVATION

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E-mail: dg@nacosti.go.ke /
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Appendix 2: ILRI Approval

2nd November 2020

Our Ref: ILRI-IREC2020-42

International Livestock Research
Institute P.O. Box 30709 00100
Nairobi, Kenya.

Dear Florence Mutua, PhD,

Ref: Management of animal diseases and antimicrobial use by information and communication technology to control AMR in East Africa

Thank you for submitting your request for ethical approval to the International Livestock Research Institute (ILRI) Institutional Research Ethics Committee (IREC). ILRI IREC is accredited by the National Commission for Science, Technology and Innovation (NACOSTI) in Kenya, and approved by the Federalwide Assurance (FWA) for the Protection of Human Subjects in the United States of America.

This is to inform you that ILRI IREC has reviewed and granted final approval for your study titled *'Management of animal diseases and antimicrobial use by information and communication technology to control AMR in East Africa'*. The approval period is 2nd November 2020 to 1st November 2021 and is subject to the following requirements:

- Only approved documents including (informed consents, study instruments) will be used.
- All changes including amendments, deviations, and violations are submitted for review and approval by ILRI IREC.
- Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ILRI IREC within 72 hours of notification.
- Any changes anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the

integrity of the research must be reported to ILRI IREC within 72 hours.
- Notification and submission of research findings to the relevant government agency before publishing the results.

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ILRI is a member of the CGIAR Consortium

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- Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- Submission of an executive summary report within 90 days upon completion of the study to ILRI IREC.

Prior to commencing your study, you are expected to comply with country specific regulatory requirements that may include obtaining other clearances as may be needed. Call on ILRI IREC on ILRIResearchcompliance@cgiar.org for any further clarification or information you may require.

Yours Sincerely,

Silvia Alonso Chair, ILRI Institutional Research Ethics Committee

Documents received & reviewed:
- IREC form & Protocol
- Questionnaire & Consent (farm visit, agrovet & animal health provider)

Patron: Professor Peter C. Doherty AC, FAA, FRS
animal scientist, Nobel Prize Laureate for Physiology or Medicine–1996

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Appendix 3: Questionnaires

Drug use by farmers

PART ONE

Contains questions from AMUSE Livestock tool v2 https://hdl.handle.net/10568/107443

Criteria for selecting respondent: **person who plays a major role in the management of livestock**

Interview specifications	
1. Questionnaire ID	
2. Date of Survey *(DD/MM/YYYY)*	
3. Time interview started (HH:MM)	*(Automatically generated by tablet)*
4. Time interview ended (HH:MM)	*(Automatically generated by tablet)*
5. Interview done via interpreter	☐ Yes ☐ No
6. Consent received (signature on form if literate)	☐ Yes ☐ No
7. Gender of respondent	☐ Male ☐ Female
Enumerator specifications	
8. Enumerator's name *(First Name and Last Name)*	
Farm specifications	
9. District/County	*(List of all districts pre-coded)/County*
10. Sub-county	*(List of all sub counties pre-coded)*
11. Parish/Ward	*(List of all parishes pre-coded)/Wards*

12. Village/ Sub-location	*(List of all village pre-coded)/Sub- locations*
13. GPS Coordinates	*(Automatically generated by tablet)*
Demographics	
14. What is your age? (*your age is the same until your next birthday*)	☐ <18 years ☐ 18-28 years ☐ 29-39 years ☐ 40-50 years ☐ >50 years
15. What is your education level?	☐ 1 Never went to school ☐ 2 Adult literacy ☐ 3 Non-formal education for____years ☐ 4 Primary school (P1-P7) (P8) ☐ 5 Ordinary secondary school (S1-S4) ☐ 6 Advanced secondary school (S5-S6) ☐ 7 Vocational training (specify) ☐ 8 University degree (undergraduate)
16. Who is the household head? That is the one who makes important decisions about the household.	☐ 1 Myself ☐ 2 My husband/wife ☐ 2 Other person

17. Who is involved in the following when it comes to the birds?
Several answers possible.

Who is involved in the daily work of feeding and taking care of the birds?	☐ Myself ☐ Wife/husband ☐ Children ☐ Other family member ☐ Hired workers	☐ male ☐ female ☐ male ☐ female ☐ male ☐ female ☐ male ☐ female ☐ male ☐ female
Who is involved in selling	☐ Myself ☐ Wife/husband	☐ male ☐ female ☐ male ☐ female

birds or products from the animals such as meat or eggs?	☐ Children ☐ Other family member ☐ Hired workers	☐ male ☐ female ☐ male ☐ female ☐ male ☐ female
Who is involved in treating or looking after the birds when sick?	☐ Myself ☐ Wife/husband ☐ Children ☐ Other family member ☐ Hired workers	☐ male ☐ female ☐ male ☐ female ☐ male ☐ female ☐ male ☐ female ☐ male ☐ female
FARM CHARACTERISTICS		
18. What animals do you keep? *Let the respondent answer freely then probe for the other options*	☐ Cows/Cattle ☐ Pigs ☐ Chickens or other birds ☐ Goats ☐ Sheep ☐ Horses or donkeys ☐ Camels	

Animal specific section – Poultry

19. How many chickens or other birds do you have?	*Write number*
Chickens	___________
Turkeys	___________
Ducks	___________
Other: ________________________	___________

20. What is the main purpose of keeping birds *[tickall options that apply]*	☐ layers (egg production) ☐ mainly for own consumption ☐ mainly for sale ☐ broilers (meat) ☐ mainly for own consumption ☐ mainly for sale ☐ produce Day Old Chicks (DOC) ☐ mainly for own flock replacement ☐ mainly for sale
21. How are you keeping the birds *(specify ifdifferent for different type of birds)?*	☐ Housed day and night ☐ Free-range at day - housed at night ☐ Free-range day and night
22. What feed do you use for the birds?	
a. Do you use grain or crop residues?	☐ Yes ☐ No
b. Do you use household waste from your homeor from somewhere else?	☐ Yes ☐ No
c. Do you use commercial pre-mixed feed? C*heck bags if it contains information on antibiotics*	☐ Yes ☐ No
d. Other (to specify) ----	
e. Do you formulate the feed yourself?	Yes/no
f. Do you routinely add any medication/drugs tothe feed?	Yes/no
23. What do you do to keep your chicken/birds healthy, so they don't get sick?	☐ Clean/disinfect ☐ Use vet drugs (incl. vaccine) ☐ Keep well fed

Do not read options!	☐ Special feed (incl. supplements) ☐ Fencing☐ Avoid mixing with other herd/flock ☐ Other: ________________________
24. When was the last time a chicken/bird was sick?	☐ <1 month ago ☐ 1-6 months ago ☐ 7-12 months ago ☐ >12 months ago ☐ Never been sick

25. What kind of symptoms did you observe? (*select most appropriate group based on clinical sign or disease name given)*	☐ Respiratory ☐ Digestive/intestinal tract ☐ Reproductive ☐ Sudden death ☐ Skin disease/wounds ☐ External parasites ☐ Neurological signs ☐ Other _________________
26. Indicate the specific disease that frequently affects the birds in your farm	Open question
27. What do you do when the chicken/birds were sick? *(do not read option, select most suitable answers)*	☐ Use herbal/traditional medicine ☐ Use medicine from the veterinary drug store (self-bought) ☐ Consult traditional healer ☐ Consults community animal health worker ☐ Consult official veterinarian ☐ Consult private veterinarian ☐ Vet applied/left drugs ☐ Nothing ☐ Other: __________________________

28. Who do you often turn to for help with diagnosis and treatment?	☐ No-one ☐ Private veterinarian ☐ Government veterinarian ☐ Pharmacist/drug store ☐ Other animal health service provider (p.e. Community animal health worker) ☐ Neighbour/friend ☐ Other: ___________________________
29. Do you keep records of treatments administered?	Yes /no
30. What do you do with the eggs of the sick bird during and a few days after treatment?	☐ Mix with eggs from other chicken (consume or sell) ☐ Throw away ☐ Other – please explain
31. What do you do with the meat of the sick bird during and a few days after treatment?	☐ Use normally (consume or sell) ☐ Throw away ☐ Never slaughter sick birds ☐ Other – please explain
32. What do you do if a sick chicken/ bird did not improve after treatment or died a few days after treatment?	☐ Use it normally (consume or sell) ☐ Bury the dead animal ☐ Burn the dead animal ☐ Throw it away
33. How many birds died in your farm in the last production cycle?	
34. How do you handle dead birds from your flock?	

35. How often do you clear litter material form the chicken house? (Weekly, bi-weekly, a after two weeks, monthly, after crop)	☐ Once a week ☐ twice a week ☐ once a month ☐ every two weeks ☐ other – please explain
36. Where do you dispose the litter materials?	
37. How many birds did you have at the start / and end of the last production cycle?	Start:________ End: ____ ☐ Don't know (don't keep records)

SECTION TWO: Drug use by farmers (is an addition to the AMU tool)

1. Drug use by the poultry farmer.

   We have compiled a list of drugs that we think are common in this area, including also their photography, and would like to establish if you have heard or used them in the past, and for what purposes. We will be happy if you can show us any remnants that you may currently be having.

1. Picture of the product	1	2	3	4	5
2. Have you seen / used it					
3. What do you call it (locally)					
4. When is the last time you used it					
5. How did you use it (in feed, water, injection etc.)					
6. For what purpose did you					

use it (symptoms)					
7. Who used it(you, vet, other)					
8. How much did you give/for how long					
9. Did you get anyleftovers/waste and what did you do with it?					

Note: The pictures will be presented in a separate paper and numbered to match the datasheet

2. How much did you use / spend on veterinary drugs / other products for chicken/birds in the last production cycle?

Product *[according to the farmer]*	Estimate of quantities used *[specify if bottles/ sachets/ doses/ liters etc.]*	Estimate of number of birds the product was used for	Estimate of the total cost in local currency *[if the farmer is aware]*
a. Vitamins?	_______ ☐ cannot remember	_______ ☐ cannot remember	__________ ☐ Don't know
b. Vaccines?	______ ☐ cannot remember	______ ☐ cannot remember	__________ ☐ Don't know
c. Dewormer?	______ ☐ cannot remember	______ ☐ cannot remember	__________ ☐ Don't know
d. Antibiotics?	______ ☐ cannot remember	______ ☐ cannot remember	__________ ☐ Don't know

e. Acaricides	______ ☐ cannot remember	______ ☐ cannot remember	__________ ☐ Don't know
f. Disinfectants	______ ☐ cannot remember	______ ☐ cannot remember	__________ ☐ Don't know
Any other drugs used during the production cycle?	_________		
			Total:

3. How do you handle empty containers and packages of antibiotics after use in the farm?
4. How do you handle containers and packages of antibiotics during use in the farm?
5. If you also keep other food animals besides poultry, how does drug use in those other animals differ from that in poultry [in terms of quantity/ frequency of use], is it the same, less, or more?
6. If you also keep other food animals besides poultry, do you use the same drugs for them as for the poultry?

   If yes:

   ☐ buy separately for each animal species

   ☐ share the same products bought for one animal species with other species

   ☐ other comments (*please write*)
7. Besides treating sick animals, do you also use veterinary drugs for other purposes?

☐ disease prevention

☐ boosting growth

☐ Treating sick people

☐ other

8. Do you sometimes use drugs intended for humans in animals?
9. What is the reason for doing that instead of using drugs for animals?

Appendix 4: Consent Form

Annex 1: Consent form for the farm visits

My name is _________________________ and I work for the International Livestock Research Institute (ILRI). I will talk to you about a poultry project that I am involved in. The study is being implemented in Kenya and Uganda, and has several partners among them the Swedish University of Agricultural Sciences, Sweden, International Livestock Research, Makerere University, and the University of Nairobi. The Kenya component is led by ILRI, in collaboration with the University of Nairobi (UON).

The project will 1) establish how poultry drugs are marketed 2) develop a system to monitor drug use and 3) determine the impact of the system. Data is being collected through interviews with farmers and veterinary drug suppliers. There will be follow up workshops to develop the system mentioned above. Overall, findings from the project will support the design of interventions to improve animal health, for increased production, and also for better health of humans. You have been selected to participate in the study because of the role you play in the poultry value chain. We expect the interview will take between 1.5 to 2 hours. All what you share with us will be treated with utmost confidentiality, and will only be used for project purposes. Please note that your participation in the study is voluntary, and you can withdraw any time during the interview. Failing to participate in the project will not impact on your relationship with ILRI or UON, now or in the future. The study is funded by the Swedish International Development Cooperation Agency (Sida) through a partnership with African Academy of Sciences (AAS).

A summary of the results will be shared with the county government office for use in improving animal and human health in your area. In addition, group results (and not individual ones) will be published in scientific journals.

We are happy to respond to any questions that you might have.

We now request you to confirm your availability by indicating your name and signature in the space below.

Date: _________________________ Name: ________________________

Signature: _____________________

For more information, contact:

Dr Florence Mutua	Scientist, International Livestock Research Institute	f.mutua@cgiar.org
Dr Joshua Onono	Senior Lecturer, University of Nairobi	jshonono@gmail.com

Appendix 5: Results summary

Table 6-1 :Type of poultry kept by farmers in Kajiado and Machakos counties

Types of chicken kept in farms	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Broilers	5	13	18
Layers	8	16	24
Improved Indigenous Chicken	31	19	50
Local Indigenous chicken	21	24	45
Day old chicks (DOC)	3	2	5
Turkey	11	5	16
Ducks	9	8	17

- Most farmers were rearing improved indigenous (50%) followed closely by indigenous chicken (45%)
- Most farmers in Machakos county were keeping improved indigenous chicken compared to Kajiado county
- On the other hand, more farmers in Kajiado were keeping broilers compared to farmers in Machakos

Table 6-2 :Other livestock kept by farmers in Kajiado and Machakos counties

Other livestock	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Cattle	32	25	57
Pig	1	9	10
Sheep and goats	22	16	38
Donkeys	4	1	5

- In addition to poultry, most farmers in the two counties were keeping cattle, pigs, sheep, goats and donkeys
- 57% of farmers were keeping cattle
- There was a larger number of farmers in Kajiado rearing pigs compared to farmers in Machakos

Table 6-3:Farmers practicing vaccinations against poultry diseases in Kajiado and Machakos counties

Type of vaccinations	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Newcastle disease	41	34	75
IBD	31	32	63
Fowl Typhoid	14	19	33
Fowl Pox	11	13	24
Farms not vaccinating	8	11	19

- Vaccinations mainly done for Newcastle and IBD
- Not many farmers were vaccinating against fowl typhoid and fowl pox
- At least 19 farmers were not vaccinating for any poultry disease

Table 6-4 :Types of therapeutic and disease prevention agents used in farms in Machakos and Kajiado

Veterinary products used	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Antibiotic administration	38	31	69
Vaccines	42	39	81
Disinfectants	18	34	52
Vitamins	35	42	77
Acaricide	12	18	30
Dewormers	20	37	57
Others (Such as Herbal, toxin binders & liquid paraffin)	7	7	14

- Most farms were using antibiotics, vaccines and vitamins (to avoid birds coming down with infection, farmers reported to be using vitamins and /or antibiotic after vaccination)
- Farmers using disinfectants in Machakos are fewer than Kajiado
- There are more farmers in Kajiado deworming poultry compared to Machakos county

Table 6-5:What farmers did to keep their chicken healthy, so they don't get sick

Biosecurity measures practiced in farms	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Cleaning and/or disinfection	44	45	89
Keep birds well fed (proper feeding)	46	41	87
Fencing	31	33	64
Use of Veterinary drugs (Incl. vaccine)	44	41	85
Special feed (incl. Supplements)	11	16	27
Avoid mixing flocks of chicken	14	22	36
Acquire inputs from reputable sources (incl. chicks)	18	24	42
Use of other preventive measures	1	1	2
Farmers keeping records of treatments administered	15	16	31

- Most farmers ensured proper cleaning of equipment, poultry houses and environment and also used disinfectant to kill and prevent entry of microorganisms.
- In addition, the farmers used veterinary drugs for prophylaxis, vaccinations and ensured proper feeding
- Most farmers in Kajiado acquire inputs from reputable sources including day old chicks (DOC) and avoid mixing flocks of chicken compared to farmers in Machakos county

Table 6-6:Disease symptoms that farmers observed in the last production cycle

Disease symptom in chicken flocks	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Respiratory syndrome	18	13	31
Digestive/ intestinal tract (diarrhoea)	11	15	26
Sudden death	3	5	8
Skin diseases	5	3	8
Neurological signs	2	6	8
Eye infection	8	7	15
***Other (eg Water belly and sick bird syndrome)**	6	13	19

*Other Clinical signs (Water belly, huddling, Sick bird syndrome, dropping head, inactive, not eating, drooping wings, Cannibalism, maliciously fed on glass)

- Farmers recalled mostly observing respiratory syndrome and diarrhoea in poultry
- The least observed were neurological signs, skin infection and sudden death
- Farmers in Kajiado county observed more birds manifesting sick bird syndrome and water belly compared to those in Machakos

Table 6-7:The specific diseases frequently reported in the chicken farms

Description of diseases	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Respiratory diseases	16	11	27
Coccidiosis	6	9	15
Infectious coryza	8	3	11
Newcastle disease	3	3	6
Worms & fleas	1	1	2
Ascites	1	2	3
Sick bird syndrome	6	4	10
****Other diseases/condition**	8	13	21

**Other conditions observed (*E. coli,* Weak legs and torticollis, diarrhea, sudden death, anorexia, cannibalism)

- Most reported diseases by farmers were respiratory diseases
- Most farmers in Machakos reported to have observed infectious coryza compared to farmers in Kajiado
- Only 2% of farmers observed internal and external parasites and 3% reported ascites

Table 6-8: Farmers recall on the period since last time a sick bird was reported in the farm

Periods	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
1 month ago	28	23	51
1-6 M ago	12	19	31
7-12 M ago	3	4	7
12 M ago	3	3	6
Never been sick	4	1	5

- 51% of farmers observed sick birds in the last one month hence likelihood of high disease burden
- Many farmers in Kajiado reported to have seen sick birds between 1 and 6 months ago compared to Machakos

Table 6-9: What farmers did when the chicken/birds were sick in their farms

Action taken when birds are sick	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Self-medication using veterinary drugs	39	31	70
Consulting public veterinarian	7	7	14
Consult private veterinarian	11	18	29
Using herbal remedies	18	18	36
Other*	1	4	5

*Other (Lab diagnosis, postmortem, consult feed supplier or the person where chicks were sourced)

- 70 % of farmers were self-medicating sick chicken using veterinary drugs
- Many farmers (36%) in the two counties were embracing use of medicinal plants to treat sick birds
- Most farmers in Kajiado were consulting private veterinarian compared to farmers in Machakos county

Table 6-10: Who do you often turn to for help with diagnosis and treatment?

Personnel consulted on diagnosis for sick chicken	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Private veterinarian	8	24	32
Other animal health Providers**	2	1	3
Pharmacist/ Agrovets	35	13	48
Government veterinarian	4	4	8
Consult friend	3	1	4
Self-diagnosis	17	14	31
Feed supplier	1	1	2

**Other persons consulted (Laboratory personnel, postmortem and community animal health workers)

- Mostly, farmers in Machakos county rely on agrovets for diagnosis and treatment while farmers in Kajiado consult private veterinarian
- Other farmers would consult feed suppliers, other animal health providers and friends
- Very few farmers were consulting public veterinarian compared to private veterinarian and agrovet, while others would do self-diagnosis

Table 6-11: How farmers are handling eggs from sick chicken during and a few days after treatment

Practices on egg handling	Machakos (n= 50)	Kajiado (n=50)	Overall (n=100)
Throw away eggs in the open environment	5	12	17
Mix with eggs from other chicken (Consume/sell)	28	20	48
Incubate for hatching	4	4	8
Feeding dogs	4	3	7
Other*	6	11	17

*Farmers not keeping layers or have not seen birds sick while laying

- Most of the farmers were selling or consuming eggs during and a few days after treatment (some farmers reported that they would sell the eggs to bakeries to make cakes, they perceived that processing of such eggs would destroy the antibiotics in the eggs)
- Few farmers were incubating eggs to hatch for flock replacement
- Most farmers in Kajiado throw away eggs in the environment compared to those in Machakos county

Table 6-12: What do you do if there are no improvements from treatment for sick birds

Interventions if treatment fails	Machakos (n=50)	Kajiado (n=50)	Overall (n=50)
No action	36	32	68
Cull / sell	6	2	8
Slaughter sick birds	4	9	13
Isolate sick birds	0	3	3
Seek second opinion from vet	0	2	2

- Most farmers continued with treatment of sick birds by changing to different antibiotic until the birds heal or die
- A few farmers in Kajiado county isolated sick birds for close observation or sought second opinion from veterinary personnel
- Some farmers in Machakos would sell the birds while those in Kajiado slaughter them

Table 6-13: Handling of meat from sick and treated chicken

Practices on handling meat	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Slaughter sick birds and dispose off in open fields	6	9	15
Consume/ selling meat	8	6	14
Don't slaughter sick birds	30	26	56
Slaughter and feed dogs/ pigs	1	6	7

- Most of the farmers don't slaughter sick birds but opt to treat
- Some farmers in both counties usually salvage the chicken by slaughtering to consume or sell them
- To reduce spread of infection in the flock, 15% and 7% of the farmers slaughter the chicken and dispose in the open or feed dogs/pigs respectively

Table 6-14: Handling of carcasses from dead birds which were on antibiotic treatment

Handling of carcass from dead birds	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Burn or bury dead birds	25	23	48
Feed dogs/ pigs	16	20	36
Consume	2	0	2
Disposal in open fields	11	10	21

- Most farmers safely dispose dead birds by burying or burning
- A number of farmers in Machakos and Kajiado counties also feed dogs/ pigs the dead birds or throw them in the open field
- Few farmers in Machakos consumed dead birds which did not survive after treatment

Table 6-15: Handling of litter materials from houses from chicken house

Handling of litter materials	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Use as manure in crop farms	45	46	91
Sell or Give neighbors	3	6	9
Feeding cows	1	6	7

- Most of the farmers used litter from poultry house as manure in their own farms
- A few farmers in Machakos feed collected litter to their cows compared to farmers in Kajiado county
- Farmers were also selling or giving out the collected litter to the neighbours

Table 6-16: Main purpose of keeping chicken

Reasons for keeping chicken	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
For sale (Layers)	6/8	16	22/24
Family consumption (Layers)	2/8	0	2/24
For sale (Broilers)	5	13	18/18
Family consumption (Broilers)	0	0	0
For sale (Improved indigenous)	24/31 (77.4%)	12/19(63.2%)	36/50 (72%)
Family consumption (Improved indigenous)	7/31 (22.6%)	7/19 (36.8%)	14/50 (28%)
For sale (indigenous chicken)	16/21 (76.2%)	7/24 (29.2%)	23/45 (51.1%)
Family consumption (Indigenous chicken)	5/21 (23.8%)	17/24(70.1%)	22/45 (48.9%)
For sale (DOC)	3	1/2	4/5
Flock replacement (DOC)	0	1/2	1/5

- The main purpose of poultry production in Machakos and Kajiado county is for sale except indigenous chicken in Kajiado which were kept mainly for family consumption
- Broiler farmers in both counties were purely reared for commercial purpose
- The day-old chicks are kept for sale mainly safe for one farmer in Kajiado who produce for flock replacement.

Table 6-17:How are the chicken raised in Farm.

- All farmers rearing broilers and day old chicks housed them during the day and night
- All farmers keeping layers had housed them during the day and night except one in Machakos
- More of improved indigenous chicken were housed during the day and night compared to indigenous chicken in the two counties

How are chicken raised?	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Fully housed (Layers)	7/8	16	23/24
Housed at night (Layers)	1/8	0	1/24
Fully housed (broilers)	5	13	18/18
Fully housed (Improved indigenous)	19/31 (61.3%)	15/19(78.9%)	34/50 (68%)
housed at night (Improved indigenous)	12/31 (38.7%)	4/19 (21.1%)	16/50 (32%)
Fully housed (Indigenous Chicken)	8/21 (38.1%)	12/24 (50%)	20/45 (44.4%)
Housed at night (Indigenous chicken)	13/21 (61.9%)	12/24 (50%)	25/45 (55.6%)
Fully housed (DOC)	3	2	5/5

- 50% of indigenous farmers in Kajiado had housed their chicken during the day and night.

Table 6-18: Type of feeds used for birds

Types of feeds	Machakos (n=50)	Kajiado (n=50)	Overall (n=100)
Commercial feeds	48	50	98
Grain crop residues	34	8	42
Household waste	25	16	41
Feed formulation at home	5	3	8

- Almost all farmers are using commercial feeds for the poultry production except two in Machakos county
- More farmers are using grain residues and household waste in Machakos county to supplement commercial feeds compared to those in Kajiado

- 8% of famers in both counties are formulating their own feeds at home

Table 6-19: Multivariate logistic regression analysis for farm-level factors associated with self-treatment of sick birds

Variables	Estimate	Std error	Z	p>(z)	Odds ratio
Fence farm compounds	1.88	0.71	2.65	0.008	6.55
Sudden death of birds	-2.32	1.03	-2.26	0.024	0.1
Consult veterinarian for treatment	-2.06	0.68	-3.02	0.003	0.13
Consulting pharmacist for diagnosis	2.47	0.8	3.1	0.002	11.83
Slaughtering or selling birds which don't improve after treatment	3.94	1.4	2.82	0.005	51.41
Continue with treatment if chicken do not improve	3.91	1.3	3.02	0.003	49.86
Constant	-3.31	1.3	-2.54	0.011	0.037

- Factors reducing the risk of self-treatment are sudden death of birds, consulting veterinarian for treatment, farms reporting last disease between 7 and 12 months ago and farmers keeping goat and sheep
- While the factors increasing the risk of self-treatment were those who had fenced their compound, those consulting pharmacist for diagnosis, those who reported to have observed sick bird syndrome and those who continue with treatment if birds do not improve

Table 6-20: Mortality rate of poultry in Kajiado and Machakos counties

Mortality	Kajiado (%)	Machakos (%)	Kajiado & Machakos (%)	P-Value
Layers	10	14.3	12.2	0.044
broilers	11	4.9	7.9	0
improved indigenous	9.7	18.4	13.8	0.0212
Indigenous	10.2	25.3	17.6	0.0101
DOC	14.7	16	15.2	0.6424

- The mortality rate was very high in poultry farms keeping broilers in Kajiado compared to farms in Machakos
- The mortality in layers, improved indigenous chicken and indigenous chicken was high in Machakos compared to Kajiado
- The mortality of DOCs was comparable in the two counties
- Mortality rate was highest in indigenous birds and lowest in broilers in Machakos while in Kajiado mortality was highest in DOC followed by broilers
- In the two counties, mortality was highest in indigenous chicken and least in broilers

Table 6-21: Direct cost of production per bird in Kajiado due to mortality

	Mortality in Kajiado (%)	Market Price of Chicken	Direct cost per bird
Improved Indigenous	9.6	1000	95.8
Local Indigenous	10.5	800	84.4
Layers	10	700	69.8
Broilers	10.9	370	40.3
DOC	14.7	100	14.7

- The direct cost per bird of improved kienyeji and kienyeji was the highest at approximately Ksh. 95.8 and Ksh. 84.4 per production cycle.
- The direct costs of production was least in DOC and broilers at 14.7 and 40.3 respectively

Table 6-22: Direct cost of production per bird in Machakos due to mortality

	Mortality in Machakos (%)	Market Price of Chicken	Direct cost per bird
Improved Indigenous	18.1	1000	180.9
Local Indigenous	24.7	800	197.6
Layers	14.4	700	100.8
Broilers	4.9	370	18.2
DOC	15.8	100	15.8

- The direct cost per bird of indigenous and improved kienyeji was the highest at approximately Ksh. 197.6 and Ksh. 180.9 per production cycle. The direct costs of production was least in DOC and broilers at 15.8 and 18.2 respectively.

Table 6-23: Direct cost of production per bird in Kajiado and Kajiado due to mortality

	Mortality (%)	**Market Price of Chicken**	**Direct cost per bird**
Improved Indigenous	13.8	1000	138.3
Local Indigenous	17.6	800	141.0
Layers	12.2	700	85.3
Broilers	7.9	370	29.3
DOC	15.2	100	15.2

- The direct cost per bird was highest in indigenous and improved kienyeji at approximately Ksh. 141 and Ksh. 138.3 per production cycle. The direct costs of production was least in DOC and broilers at 15.2 and 29.3 respectively