IMPLIMENTATION OF BIOSECURITY PRACTICES AND THEIR EFFECT ON CHICKEN HEALTH IN LIRA CITY, NORTHERN UGANDA

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DECLARATION

I, **Okwany Alex,** declare that, to the best of my knowledge and understanding, the work contained in this dissertation is my original work and has never been submitted to any other University or institution for any award of a degree.

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APPROVAL

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DEDICATION

I dedicate this work to my lovely wife, Jennifer Adong, and my dear children, Atim Patricia, Olwaa Pius, Kunda Bridget, Cila Louis, and Obaa Abel.

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
CAS	Composite Average Score
COVID	Coronavirus Disease
CRD	Chronic Respiratory Disease
FAO	Food and Agriculture Organization of the United Nations
GUREC	Gulu University Research and Ethics Committee
IBD	Infectious Bursal Disease
ND	Newcastle Disease
NDP	National Development Plan
OR	Odds Ratio
SOPs	Standard Operating Procedures
SPSS	Statistical Package for Social Sciences
SDGs	Sustainable Development Goals
UBOS	Uganda Bureau of Statistics

ABSTRACT

Chicken production in Uganda is constrained by disease outbreaks and worm burden possibly due to inadequate biosecurity practices by chicken farmers. A cross-sectional study was conducted to assess the extent of use and effect of biosecurity practices on chicken health among 180 smallholder and commercial chicken farmers in Lira City, Northern Uganda. The study adopted a cross-sectional design, and both qualitative and quantitative approaches. A questionnaire with afive-point liket scale and observation check list were used to measure the extent of use of biosecurity practices and laboratory examination for worm burden. The results showed that cleaning biosecurity measures were most frequently practiced by chicken farmers for disease prevention (Composite Average Score (CAS) = 3.13). Farmers sometimes practiced isolation biosecurity measures (CAS = 2.88) and traffic control measures (CAS = 2.89). Cleaning biosecurity measures had a significant negative effect on annual chicken morbidities (β = - 0.298, p = 0.012) and annual chicken mortalities (β = - 0.246, p = 0.022). Farm land size had a significant positive effect (β = 0.562, p = 0.005) on annual chicken morbidities and mortalities. The present stock had a significant negative effect (β = - 0.540, p = 0.011) on monthly chicken mortalities. Isolation had a positive effect (OR = 0.173, p = 0.029) on worm prevalence. Monthly income (OR = 0.407, p = 0.047), land size (OR = 0.456, p = 0.009), and male sex (OR = 0.307, p = 0.006) had a positive effect on worm prevalence. In conclusion, socioeconomic and operational factors such as farmland size, gender, monthly income, and stock size are crucial in determining chicken morbidities and mortalities. It is recommended that farmers adhere to all biosecurity measures during their chicken farming operations to reduce infections and increase the birds' productivity and profitability.

Keywords: Biosecurity Practices, Chicken Morbidities, Chicken Mortalities, Worm burden

CHAPTER ONE

INTRODUCTION

1.1 Background

Chicken is the most dominant species of livestock reared worldwide (Aryemo *et al*., 2014). The global chicken flock was estimated to be about 33,097,116,000 birds (FAO, 2020). In Uganda, the chicken industry is dominated by chicken kept mainly by smallholder farmers at a subsistence level (Mwesigwa *et al*., 2015). According to UBOS (2019), the national chicken flock in Uganda was estimated to be 34.7 million, of which 80% comprises local breeds. Chicken production plays a significant role in improving household livelihoods (Chingonikaya & Salehe, 2018; Nakkazi *et al*., 2014). It also provides great advantages over other agricultural enterprises like dairy, apiculture, piggery, and others, as it requires less land, requires relatively small investment capital, chickens have a high Feed Conversion Ratio (FCR), grow fast, and give quick returns (Umut, 2017). Consumption of chicken meat is considered healthier than consuming meat from other sources, thus increasing people's demand for chicken (Uzmay *et al*., 2013).

Much as chickens play significant roles in the livelihood of people, their production is constrained by about 100% and 95.2% disease outbreaks and worm burden, respectively (Abbas *et al.*, 2015). This results in poor health of chickens kept by many chicken farmers (Mahoro *et al*., 2017) and high chicken mortality (Mishamo *et al.*, 2019). These disease outbreaks, chicken mortality, and worm burden in chicken farming could be due to inadequate biosecurity practices by chicken farmers. Chicken diseases are generally responsible for the mortality and the reduced growth rate and egg production, hence reduced economic returns to farmers (Butcher & Yegani, 2009). Abah et al, (2017) pointed out

Newcastle Disease (NCD) as the main cause of chickens' mortality. Chicken diseases are the major threat to chicken production in all districts of Uganda (Kyomugisha & Byarugaba, 2009). This has discouraged some households in Uganda from venturing into the chicken enterprise.

The prevalence of chicken diseases has been attributed to, among other factors, inadequate biosecurity practices (Byaruhanga *et al.*, 2017). These other factors could include poor nutrition, climatic factor and, host genetic and age. This has called for regular vaccination of chickens and treatment of sick ones, which has resulted in a high cost of production to farmers. Biosecurity is the most efficient and cost-effective method of disease prevention (Cardona & Kuney, 2018). Biosecurity means the implementation of a set of measures and practices that reduce the risks of the introduction and spread of disease agents in farm animals. The three principal elements of biosecurity are segregation, cleaning, and disinfection (Sami & Eltayeb, 2021). It also refers to the measures and methods adopted to secure a disease-free environment for the profitability of the farm (Untoo & Banday, 2012). Chicken farmers can apply biosecurity measures at various points like the source of birds, barriers, and access to the flocks, disinfection station, workers disinfection practices, visitors' precautions, disposal of dead birds, disposal of wastes, clean-up and disinfection between flocks, contact with other birds (Ayodeji, 2018).

In Uganda, available research suggests that inadequate biosecurity is associated with poultry health problems, although direct evidence that isolates its causal effect is limited. A longitudinal study of 19 semi-intensive broiler farms in Wakiso found low overall biosecurity scores (median 38.5%), recurring respiratory and gastrointestinal signs, and frequent antibiotic use; the researchers considered insufficient biosecurity and poor vaccine responses possible contributors to the health concerns. low biosecurity scores co-occurred with recurring illness

signs and antibiotic use in Wakiso broiler farms (Ayebare et al., 2025). The layer farms keeping newly introduced birds in a separate house was associated with lower odds of non-typhoidal *Salmonella,* while larger farm size and the presence of other animal species were associated with higher odds. separating new birds was associated with lower *Salmonella* risk, whereas larger farms and other animal species were associated with higher risk (Odoch et al., 2017).

The common biosecurity practices that chicken farmers mainly implement in Uganda are cleaning, disinfection, isolation of sick chicken, quarantine of new chicken, proper disposal of dead birds, vaccination, and traffic control or controlling the movement of people, birds, and chicken equipment (Sharma, 2010). In Lira city, chicken farmers have adopted biosecurity practices like cleaning and disinfecting the chicken house, isolating sick birds, controlling visitors on the farm, vaccinating birds regularly, giving birds clean feeds and water, and record keeping. Despite the adoption of these biosecurity practices by small holders and commercial chicken farmers in Lira city, the extent of use of these biosecurity practices by chicken farmers is still uncertain, and this could be having some effect on chicken health. Therefore, this study is aimed at determining the extent of use of biosecurity practices and their effect on chicken health.

1.2 Statement of the Problem

The low adherence to use of biosecurity practices in chicken production in Uganda has increased the risk of chicken diseases spread on different farms (Ayebare *et al.*, 2025) leading to 100% disease outbearks and 95.2% worm burden (Abbas et al., 2015). This results in poor health of chicken kept by many farmers (Mahoro et al., 2017) and high chicken mortality (Mishamo *et al.*, 2019). The previous studies by Mahmoud et al., (2014), Abah et al., (2017) and Ismael et al., (2021) on biosecurity in chicken production focused mainly on adoption of

biosecurity measures by chicken farmers, and biosecurity status in chicken production. However, these studies did not fully assess the extent of use of biosecurity practices by chicken farmers and how these biosecurity practices affect chicken health. In Uganda, similar study has been conducted by Ayebare et al., (2025) in Wakiso district in the Central. Unfortunately, none has been conducted in Northern, where Lira City is located. Therefore, this study aimed to assess the extent of uses of biosecurity practices by smallholder and commercial chicken farmers and how these biosecurity practices affect chicken health. A case of Lira city, Northern Uganda.

1.3 Objectives of the study

1.3.1 General objective

To assess the extent of use and effect of biosecurity practices on chicken health among chicken farms in Lira city, northern Uganda.

1.3.2 Specific objectives

i. To determine the extent of use of biosecurity practices by chicken farmers in Lira city.

ii. To establish the effect of biosecurity practices on chicken health in Lira city.

1.3.3 Research hypothesis

i. All chicken farmers in Lira city are using biosecurity practices.

ii. Biosecurity practices have a positive effect on chicken health in Lira city.

1.4 Significance of the Study

The findings of this study will inform decision-making for the establishment of targeted interventions towards the reduction of chicken morbidities, associated mortalities, and worm burden, and hence boost the livelihoods of chicken farmers. Closely related to this, the findings of this study shall be shared with chicken farmers to help guide them to make informed decisions and take accurate actions in disease prevention and management on their chicken farms. This will specifically benefit the chicken farmers by providing them with the necessary knowledge and information to improve biosecurity practices and chicken health for profitable chicken production. Furthermore, the findings of the study will inform decision-making for the attainment of SDGs 1 & 2 of Ending poverty in all its forms everywhere and Ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture, respectively. Lastly, this study will also help to achieve NDP 1 of Uganda, which aimed to transform the country from a peasant-based economy to a modern and prosperous one within 30 years.

1.5 Justification of the Study

Biosecurity is very key in chicken production (Butcher & Yegani, 2009). However, there is still a severe weakness in the application of biosecurity practices by chicken farmers (Waktole et al., 2023). This weakness in the application of biosecurity practices can cause great harm to chicken health and reduce the profit mark-up of the chicken farms as the implementation of all the recommended biosecurity practices enhances chicken health and farm profitability (Chan, 2008). Therefore, it is imperative to fully assess the extent of use of biosecurity practices by chicken farmers and the effect of biosecurity practices on chicken health.

1.6 Scope

This study focused on assessing biosecurity implementation and the effect of biosecurity practices on chicken health among the 180 chicken farmers in Lira City, Northern Uganda, between the months of March and May 2024.

1.7 Conceptual Framework

The conceptual framework guiding this study is presented in Figure 1. The framework illustrates the interplay of multifarious variables influencing biosecurity practices and chicken health. The framework further illustrates that biosecurity practices i.e cleaning and disinfection, isolation, and traffic control could have a positive or negative impact on chicken health. Lastly, the framework shows that factors such as income, training, experience, education, and management system could moderate the extent of use or application of biosecurity practices and hence, create some impact on chicken health. Therefore, the relationship among the variables are well defined with their relevance to this study.

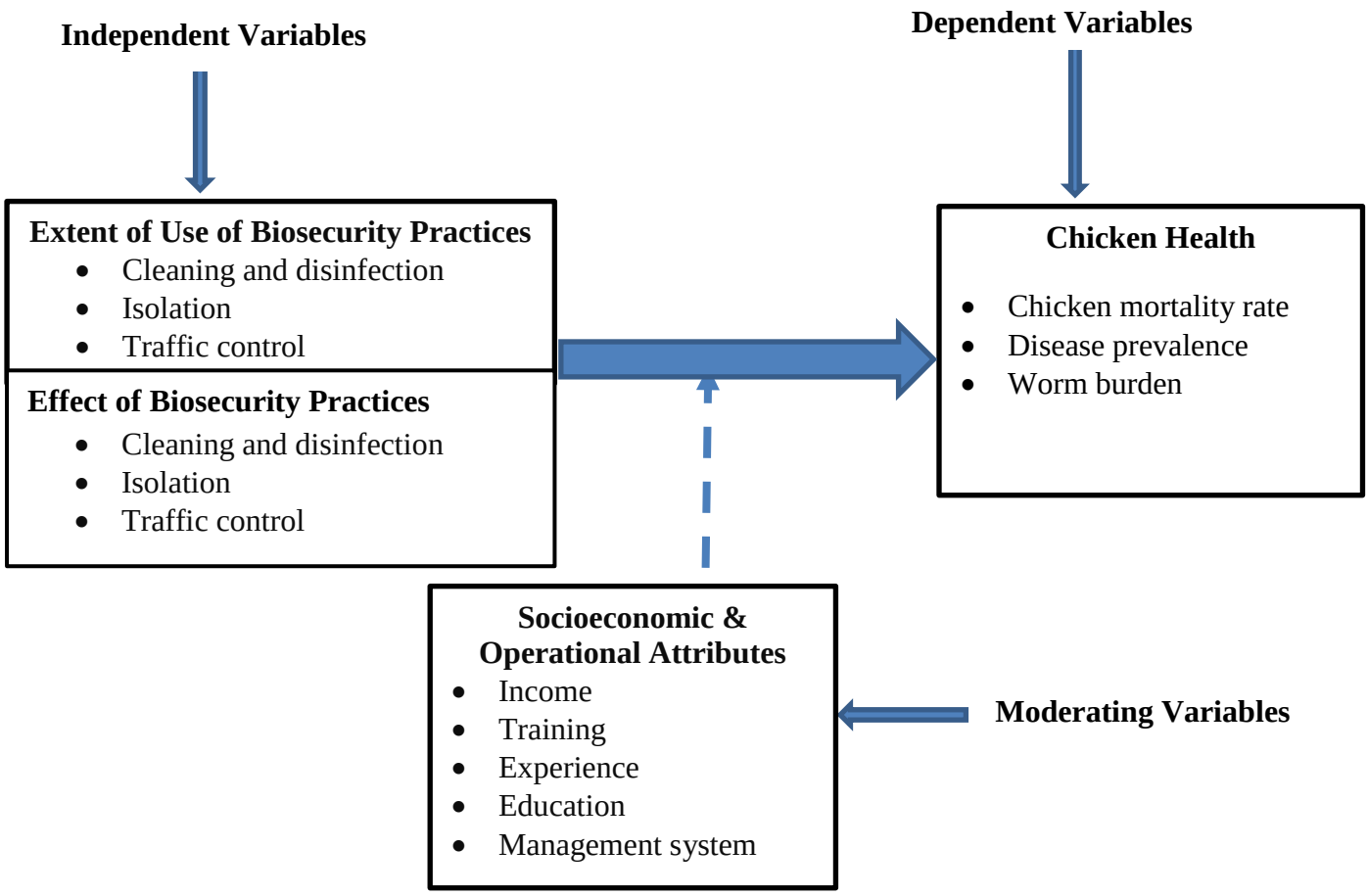


***Figure 1**: The conceptual framework of the study (Adapted with modification from Mutua, 2018*

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Biosecurity

Biosecurity means safety to living things; Bio'' refers to 'life', and ''Security'' means 'protection' (Untoo & Banday, 2012). It refers to procedures used to prevent the introduction and spread of disease-causing organisms in chicken flocks (Untoo & Banday, 2012). Biosecurity also refers to the designed measures and methods to reduce the spread of pathogens within and between the farms (Cardona & Kuney, 2018). It means what we do to keep diseases from entering our chicken farms (Cardona & Kuney, 2018). The two fundamental principles of biosecurity are the prevention of the introduction of disease agents (bio exclusion) and the prevention of the spread of disease agents on a farm (bio containment) (Maduka *et al*., 2016). Biosecurity has three key components, i.e., cleaning and disinfection (Sanitation), Isolation, and Traffic control (Cardona & Kuney, 2018). Sanitation refers to the regular cleaning and disinfection of the chicken house (s), people, materials, and equipment (Hunter *et al*., 2008) while Isolation refers to time, distance and physical barriers that reduce or prevent the introduction of pathogens onto the farm, and or into the chicken house (Sami & Eltayeb-Gumaa, 2021) and lastly, Traffic control includes restricting human, equipment, and animal movement onto the farm, and their movement patterns while on the farm (Cardona & Kuney, 2018).

Biosecurity was originally used in defense to control biological weapons (Humblet & Saegerman, 2022). It was then introduced in animal health and production systems in the 1980s as a measure of protecting human, animal, and environmental health against biological threats (Humblet & Saegerman, 2022). Currently, Biosecurity has become a key component in chicken production (Ayebare *et al.,* 2025). There has been a paradigm shift from the use of

antibiotic growth promoters and therapeutic antibiotics in chicken management to the use of preventive biosecurity measures to guard against antimicrobial resistance (Hussein *et al*., 2023; Otieno *et al*., 2023), which is posing a significant public health risk and threat to humans (Butcher & Yegani, 2009; Gržinić *et al*., 2023; Humblet & Saegerman, 2022). It is reported that consumers of chicken's meat and eggs are now becoming more health-conscious due to the outbreak of zoonotic infectious diseases like avian influenza (AI) (Brown, 2021) and salmonellosis in chicken industry (Butcher & Yegani, 2009), hence there is urgent need for adoption of stringent biosecurity measures by chicken farmers (Tasie *et al*., 2020; Untoo & Banday, 2012) to prevent disease outbreak in chicken (Sharma, 2010).

Biosecurity is of great help in the reduction of disease outbreaks and the improvement of the health and productivity of chicken (Cunningham & Fairchild, 2020; Tadesse *et al.*, 2024). Ayodeji (2018) pointed out that a high level of biosecurity guards against economic loss in chicken rearing, and thus resulting in high profitability of the chicken business (Untoo & Banday, 2012). It also promotes better public health by ensuring a clean chicken production system and a hygienic chicken food value chain (Ayodeji, 2018; Sharma, 2010). Besides the above good benefits of biosecurity, many farmers still have inadequate knowledge of it (Benson Musyoka Mutua, 2018). This calls for the participation of all the stakeholders to ensure better biosecurity practice for hygienic chicken production so that better income and sustainable development can be realized (Sharma, 2010; Ssempijja, 2019).

Biosecurity measures practiced worldwide can be categorized into three main elements, namely Isolation, Cleaning and disinfection (Sanitation), and Traffic control (Conan *et al.*, 2012).

Whereby, Isolation includes keeping birds of different ages separately, Separating sick birds from healthy birds, Isolating new birds/birds brought from the market for at least 2 weeks

before mixing them with other birds, No exchanging/lending your farm equipment to other farms, Restricting movement of farm workers and visitors on the chicken farms, etc. (Delpont *et al*., 2021), yet Cleaning and disinfection (Sanitation) comprises of practices like Cleaning of the chicken house, Cleaning of feeders and drinkers and other chicken equipment (Abiri *et al.*, 2023), Provision of clean drinking water to birds, Washing of hands before and after entering the chicken house, Adding disinfectant to the water in the footbath , Fumigating the chicken house before new birds are brought in etc. (Meher *et al*., 2020; Siekkinen *et al.*, 2012), and Traffic control covers practices such as Keeping a record of all farm visitors, No chickens on the farm mingle with other local and wild birds, Prohibiting vehicles from entering the farm, etc. (Lestari *et al*., 2011). Therefore, all these measures have to be taken seriously for successful chicken production.

2.2. Extent of Use of Biosecurity Practices among Chicken Farmers

2.2.1 Extent of use of cleaning and disinfection (Sanitation)

The importance of sanitation, encompassing cleaning and disinfection, is paramount in chicken biosecurity (Scott *et al.*, 2018). Effective sanitation practices significantly reduce the risk of disease transmission and mortality in chicken (Mishamo *et al.*, 2019). However, research has revealed varying levels of adherence to sanitation practices among chicken farmers, ranging from 40% to 80% compliance (Waktole *et al*., 2023). A study in Kharatum, Sudan, revealed that 57% of broiler farms failed to use disinfectants in foot baths (Mahmoud *et al*., 2014). Conversely, an assessment in Bishoftu town, Oromia Regional State, Ethiopia, found that 90.91% of commercial chicken farms had footbaths at their gates (Ismael *et al*., 2021). This is because regular disinfection of drinkers, feeders, and footwear is crucial to prevent chicken diseases (Sharma, 2010; Waktole *et al.*, 2023). However, Delpont *et al*. (2021) and Siekkinen *et al*. (2012) reported that some chicken farmers failed to conduct

disinfection due to insufficient funds to purchase disinfectants. This lack of disinfection can lead to pathogen buildup on facilities, equipment, and birds, making chicken meat risky for human consumption (Otte et al., 2021).

In Zamfara State, Nigeria, a study found that only 12% of farmers practiced hand washing, and 13% regularly cleaned around their chicken houses (Hassan Jibril, 2016). Conversely, other studies reported frequent handwashing practices among farmers as a key sanitation biosecurity measure (Imam *et al*., 2021; Lambrou *et al*., 2020; Odo *et al*., 2015). On the other hand, a comparative study in Australia found that broiler farms had higher adoption rates of sanitation biosecurity measures than layer farms (Scott *et al*., 2018). This may be attributed to the need for intensified care in broiler farms due to the shorter maturity period.

In a nutshell, the extent of cleaning and disinfection in chicken management worldwide varies, with 60-80% of farms in developed countries (Luyckx, 2016) and 30-60% in developing countries implementing regular protocols (Conan *et al*., 2012). However, efficacy and frequency vary, with 40-60% of farms globally disinfecting facilities and equipment regularly (Christina *et al*., 2001). Regional disparities exist, with Asia and Africa lagging behind Europe (Centers for Disease Control and Prevention, 2015). Larger, commercial farms prioritize biosecurity more than smaller ones (Benson Musyoka Mutua, 2018). Challenges such as limited resources, lack of knowledge, inadequate regulations, and disease pressure hinder effective implementation of proper sanitation on a chicken farm (Knobling *et al*., 2023). Approximately 70% of chicken farms implement some cleaning and disinfection, but 40% use ineffective methods and 30% neglect regular sanitation protocols (Tadesse *et al*., 2024).

2.2.2 Extent of use of isolation

The application of isolation biosecurity measures in chicken farms globally is inconsistent, with significant gaps in developing countries (Attia *et al*., 2022). Limited infrastructure, financial constraints, and lack of awareness contribute to ineffective implementation of isolation, compromising disease control on chicken farms (Negro-Calduch *et al*., 2013; Otieno *et al.,* 2023). Regional disparities exist, with developed countries having better isolation practices than developing ones (FAO 2013). Limited space, inadequate training, disease pressure, and inadequate enforcement of regulations and guidelines can compromise the effectiveness of isolation protocols (Delia *et al.*, 2024; Sami & Eltayeb-Gumaa, 2021).

Isolation was found to be the most neglected element of biosecurity by most farmers in the Free State and Northern Cape Provinces of South Africa (Msimang *et al*., 2022). Ismael *et al*., (2021) reported that only 20.45% of chicken farms in in Bishoftu town, Oromia Regional State, Ethiopia had isolation rooms for new and diseased chickens while in Kaharatum, Sudan, it was found out that chicken farms that were keeping birds of different species together with chicken were 26.7 % (Mahmoud *et al.*, 2014). Furthermore, Delia *et al*. (2024) and FAO (2013) reported low practice of isolation biosecurity measures by chicken farmers in Africa due to inadequate infrastructures like isolation rooms.

2.2.3 Extent of use of traffic control biosecurity measures

The implementation of traffic control measures varies significantly across different countries. In Africa, Nigeria reported a 55.6% implementation rate of traffic control measures (Tasie, C. M., Wilcox, G. I. and Kalio, 2020), while Ethiopia achieved a 64.3% implementation (Ismael *et al*., 2021), and South Africa implemented traffic control measures at a rate of 75.6% (Msimang *et al*., 2022). In Asia, India reported a 58.3% implementation rate (Scott *et al*., 2018), whereas China achieved an 82.5% implementation rate (Wei *et al*., 2013). In the

Americas, Brazil implemented traffic control measures at a rate of 71.1% (Baccili *et al*., 2024), while the United States reported a 78.6% implementation rate (Cardona & Kuney, 2018). In Oceania, Australia achieved an 85.7% implementation rate (Scott *et al.*, 2018).

The variation among chicken farms in implementing traffic control measures can be attributed to several factors. Farm size and layout play a significant role, with larger farms requiring more complex traffic control measures(Cardona & Kuney, 2018). Additionally, production type, management structure, and resource allocation influence implementation (Mutua, 2018). Farmer knowledge and awareness, attitudes, and experience are crucial, with trained staff and experienced farmers more likely to implement effective measures (Waktole *et al*., 2023).

Chicken farms face significant biosecurity risks due to poor animal and human traffic control practices (Tago *et al*., 2016). Studies have shown that keeping other animals on chicken farms increases the risk of zoonotic disease (Otte *et al*., 2007; Sami & Eltayeb-Gumaa, 2021; Ssematimba *et al*., 2013). Inter-species interactions and proximity to other livestock compromise biosecurity, leading to disease outbreaks on the chicken farms (Das Gupta *et al*., 2022; Tago *et al.*, 2016).

Allowing chickens to mingle with wild birds also increases the risk of zoonotic disease transmission, particularly pathogenic Newcastle disease and avian diseases (Wille & Holmes, 2020). Free-range chicken systems contribute to higher disease outbreaks due to frequent contact between domestic and wild birds (Das-Gupta *et al*., 2022). Similarly, feed contamination is another significant biosecurity risk, with unregulated access to feed stores by birds leading to contamination through fecal matter, feathers, and dirt (Abreu *et al*., 2023; Lambrou *et al.*, 2020; Odo *et al.*, 2015) Overcrowding in chicken houses increases stress levels, reduces bird immunity, and creates an environment conducive to disease spread (ISA,

2024). Additionally, human traffic control measures are often neglected, despite being critical for maintaining biosecurity (Conan *et al*., 2012; Lestari *et al*., 2011; Ritter *et al*., 2017; Robertson, 2020; Ssematimba *et al*., 2013; Ssempijja, 2019).

2.3. Effect of Biosecurity Practices on Chicken Health

2.3.1 Effect of Biosecurity Practices on disease morbidity in chickens

Non-adherence to biosecurity measures results in high disease morbidity in chicken farms (Abbas *et al*., 2015), as many chicken farmers are often reactive in the use of biosecurity measures after the disease outbreak (Rohr *et al*., 2019; Wolff *et al*., 2019). Markos & Region (2016) noted that biosecurity measures were very crucial in reducing disease morbidity in the chicken farms. This was because regular practice of biosecurity measures like cleaning and disinfection of the chicken house and equipment ensures birds' safety from diseases (Christensen *et al*., 2021; Hunter *et al*., 2008). Similarly, a study by Delia *et al.* (2024) reported that cleaning and disinfection were very instrumental in minimizing disease morbidity among chicken birds. In Bangladesh, report indicated low prevalence of Newcastle Disease (ND), Infectious Bursal Disease (IBD) and Coccidiosis of 24.96%, 8.92% and 7.32% respectively (Syed *et al*., 2010), in those chicken farmers that were frequently using biosecurity measures in their chicken management (Subasinghe *et al*., 2023).

2.3.2 Effects of Biosecurity Practices on Chicken Mortality

In Hawassa city, Sidama zone, Southern Ethiopia, poor chicken management due to a lack of biosecurity awareness was found to be one of the serious causes of chicken mortality (Mishamo *et al.*, 2019; Selam & Kelay, 2013). Tasie *et al.* (2020) noted that the absence of or negligence of biosecurity practices can result in a high mortality rate in chicken production. Similarly, Mramba & Mwantambo (2024) reported high mortality of exotic broilers and

layers in chicken farms in Dodoma, Tanzania. However, a contradictory report by Vong (2013) revealed that biosecurity practices have no significant impact on the chicken mortality rate. Yet, proper frequent biosecurity practice was considered the best way of preventing chicken diseases, which are a major cause of chicken mortality (Mishamo *et al.*, 2019). Furthermore, Msimang *et al.* (2022) also reported that effective isolation of sick and new birds in chicken management prevents disease outbreaks, and hence reduces chicken mortality rates.

2.3.3 Effects of Biosecurity Practices on Worm Burden in Chicken Production

Parasitic worms are a significant concern in chicken production, causing economic losses and compromising birds' health (Asukwo *et al*., 2013). Chickens with worm infestation present signs such as slow growth, diarrhea, pale comb, reduced egg production, ruffled feathers, reduced appetite, gasping for air, continually shaking it's head, worms expelled in the fecal, loss of weight and emaciation (Monrad, 2007), especially in free range chicken management where biosecurity practices is inadequately applied (Sente *et al*., 2016). In the gastrointestinal study carried out in Zambia, six species of helminth were discovered this comprising five nematodes and one cestode (Mahmoud *et al.*, 2014), and the result showed that the prevalence of nematodes was *Allodapa suctoria* (85.6%), *Tetrameres Americana* (80.8%), *Ascaridia galli* (28.8%), *Gonglonema ingluvicola* (50.4%), and *Heterakis gallinarum* was the only cestode found.

Asukwo et al. (2013), on the other hand, found that the prevalence of intestinal helminthes in 200 faecal samples of the local chicken collected in Nigeria, that of *Acaridae gallinarum was* 46 %, *Heterakis ssp* 31%, *Capilliaria Spp* 29%, *Strongyles Spp* 23% and *Raillietina Spp 11%*. This could be due to a lack of biosecurity practices. Biosecurity measures like regular cleaning and disinfection of chicken housing, washing and disinfecting feeders and drinkers,

provision of clean feeds and water, and having good drainage on the range area to limit water from pooling and puddling (Mahmoud *et al.,* 2014) could reduce the worm burden in chickens.

In Uganda, a study on gastrointestinal helminths of semidomesticated guinea fowl under different management systems reported a higher prevalence of all species of gastrointestinal helminths in birds under the free range management system than in the semi-intensive management system (Sente *et al*., 2016).

2.4 Summary of Literature Review

This chapter reviewed different literature from different scholers whos articles/ studies were peer reviewed and published, related to this study. The reviewed literature are of most recent studies. For example, a study by Ayebare et al. (2025) on Biosecurity measures and effects on health performance and antibiotic use in semi-intensive broiler farms in Uganda, and another one by Otieno et al. (2023) on Adoption of farm biosecurity practices among smallholder poultry farmers in Kenya.

No study of this nature has been conducted in Northen Uganda and specifically on the effect of biosecurity practices on chicken health. This therefore is the gap among others studes and this one.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Lira City, Northern Uganda (Figure 2), which is located at the coordinates of $2^0$14’50.0’’N $32^0$54’00.0’’E (Latitude: 02.2472; Longitude: 32.9000) and lies at an average elevation of 1,063 meters (3,488 ft.) above sea level. The City covers approximately a total area of 284.6 km^2. Lira City has administrative structures of 2 City divisions, 49 Wards, and 236 Cells. It has a daytime population estimate of 500,000 people. The city has a total household of 57,585, with the average household size of 4.5 (UBOS, 2019). Lira City is bordered by Kole district in the West and by Lira district in the South, East, and North. Lira City is chosen for this study because it has registered a constant increase in the number of chicken farmers due to the rising demand for chicken to feed the increasing population of the City (UBOS, 2021).

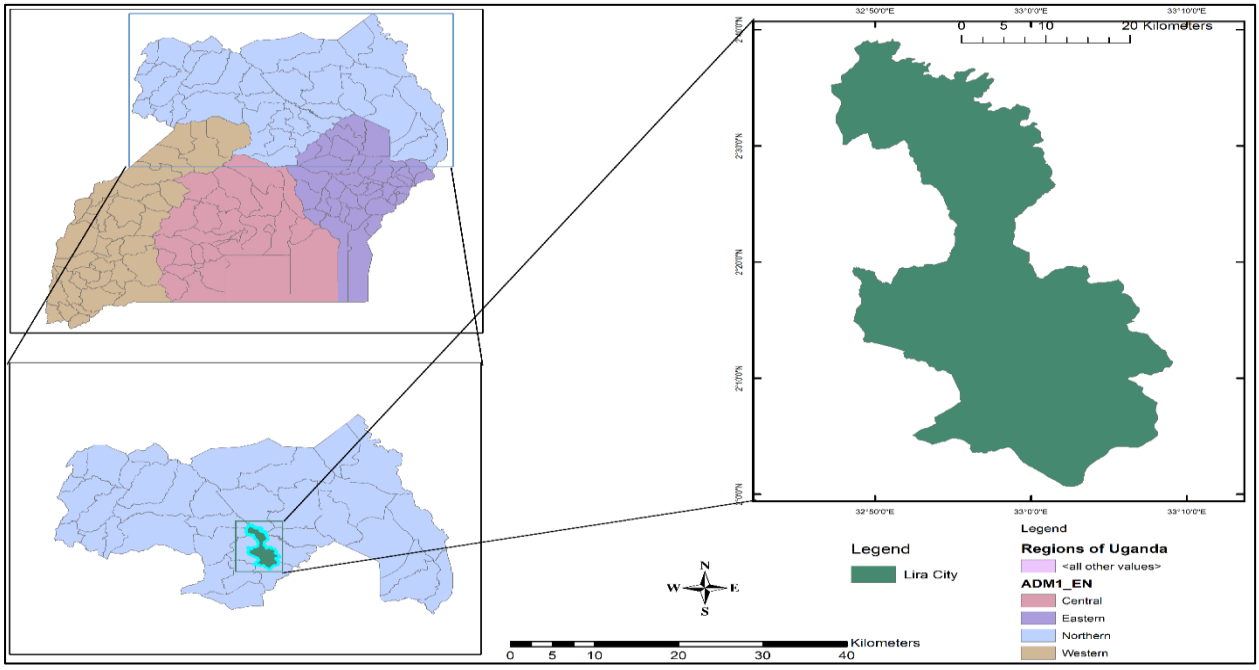


Figure 2: *Map of Lira City relative to the Uganda country map (Source: GIS map)*

3.2 Study Design

A cross-sectional study design was adopted for this study. A survey was conducted to determine the extent of use of biosecurity practices by smallholder and commercial chicken farmers. This helped in the assessment of the effect of biosecurity practices on chicken health. The study was both qualitative and quantitative in nature, where both descriptive and numerical data were collected and analyzed.

3.3 Study Population

The study population consisted of 400 registered smallholder and commercial chicken farmers who are in the geographical area of Lira City in Northern Uganda and are responsible for the health and well-being of their chickens.

3.4 Sample Size, Sampling Techniques, and Sampling Framework

Sample size was determined using the formula, $n = N/1+N (e^2)$ according to (Yamane, 1967).

Where.

N = Number of chicken farmers in Lira city = 400

e = level of precision = 0.05%

So, $n=400/1+400 (0.0005^2) = 200$

At least 220 chicken farmers were targeted in this study, including the 10% non-response rate, However, a total of 180 smallholder and commercial chicken farmers, comprising 100 with extensive chicken farmers, 37 with intensive chicken farmers, and 43 with semi-intensive chicken farmers were randomly sampled. The selection of these farmers category was informed by the number of extensive chicken farmers being predominantly higher in

the study area as compared to intensive and semi-intensive ones. The study participants were selected using a simple random sampling technique from each farm category.

3.5 Data Collection

3.5.1 Determination of the extent of use of biosecurity practices by chicken farmers

Data on the extent of use of biosecurity practices was collected using both a semi-structured questionnaire and an observation checklist. The questionnaire consisted of: (1) Socio-demographic characteristics of smallholder and commercial chicken farmers, (2) General information on biosecurity, (3) A 5-point Likert scale to measure the extent of biosecurity practices, where 1= low extent and 5= high extent. The questionnaire was pretested in 15 chicken farms that were included in the study to determine its reliability and to make data assistants understand how to use the questionnaire better. The face-to-face interviews were conducted with either farm owners, managers, or employees, depending on who was available, while capturing responses on the questionnaire. The observation check list consisting of a list of observable biosecurity practices that the study was focusing on, was also used to collect data on extent of implementation of visible biosecurity practices like the presence of farm fence and gate, functional footbath, visitors' book, isolation room and use of special clothes and foot wears by both the farm workers and visitors, and the observed practices ware checked YES and unobserved checked NO from the checklist.

3.5.2 Determination of the effect of biosecurity practices on chicken health

Data on the effect of biosecurity practices on chicken health (monthly and annual morbidity, monthly and annual mortality, and worm burden) were collected using both the Semi-structured questionnaire and laboratory examination of chicken feces.

3.5.2.1 Data collection using a survey

The questionnaire was used to numerically capture the number of monthly and annual sick and dead chickens from each farm during an interview based on farm records.

3.5.2.2 Fecal samples collection

Fecal samples for laboratory examination were collected by randomly taking three fresh chicken lose or soft fecal samples of approximately 5grames in a sterilized stool container from a total of 30 chicken farms comprising 10 free-range farms, 10 semi-intensive farms, and 10 intensive farms in Lira city. This was done through stratified random sampling. The samples were then labeled, packed, and immediately transported under a cold chain in an ice box (Figure 3) to the Lira district production laboratory for laboratory examination.



Fecal sample collection Fecal samples' transportation

Figure 3*: Shows the collection and transportation of fecal samples*

3.5.2.3 Laboratory examination procedure

Using the simple flotation method (Edem Effiong et al., 2013), 2 g of chicken fecal sample was dissolved in 15 mL of sodium sulphate solution. The solution was then filtered using a sieve and filter gauge and filled into a 10 ml test tube to form a positive meniscus. It was then covered with a cover slip and left to stand for 10 min. Then the cover slip was carefully removed, placed on a glass slide, and examined under an Olympus CX23 microscope made in Japan with X10 magnification and finally X40 magnification for a clear view. Viewing under

the microscope, the presence of worm egg(s) was recorded as Positive (+), and the absence of worm egg(s) was recorded as Negative (-). The worm egg(s) viewed in Positive samples, their species were identified by comparing the eggs observed in the sample with reference images or diagrams of known worm eggs (Bitew & Ayele, 2019). The results were then recorded in the book, which was later summarized in Microsoft Excel and lastly transferred into Analysis Software for data analysis.

3.6 Data Analysis

The survey data collected were entered, cleaned, coded, and analyzed using the Statistical Package for Social Sciences (SPSS Version 25.0). Descriptive statistics, inform means, frequencies, graphs, and pie-charts were used to summarize and analyze data.

3.6.1 Determination of the extent of use of biosecurity practices by chicken farmers

Descriptive statistics (measures of central tendency like means, and modes (frequencies and percentages), as well as principal component factor analysis, and reliability analysis were conducted. Additionally, student t-tests and chi-square analysis were conducted to ascertain differences and associations between variables.

3.6.2 Determination of the effect of biosecurity practices on chicken health

3.6.2.1 Effect of biosecurity practices on chicken morbidity and mortality

A partial correlational analysis was conducted to assess the association between biosecurity practices and chicken health, that is, mortality and morbidity. A multiple linear regression was then run to assess the effect of biosecurity measures on chicken mortalities and morbidities

3.6.2.2 Effect of biosecurity practices on chicken worm burden

A probit logistic regression analysis was performed to determine the effect of biosecurity measures on chicken health, specifically with respect to worm burden. This was done after preliminary analysis for regression, such as tests for normality, correlation tests to avoid overfitting, and multicollinearity.

3.7 Ethical Approval

Before conducting the study, the researcher obtained ethical clearance from the Gulu University Research Ethics Committee, and the study was approved with approval number GUREC-2023-596. While in the field, permission was obtained from the City production officer to carry out the research in the City. In addition to that, permission was also sought from the City division, ward, and cell leaders to carry out the study in selected areas. At the farm level, respondents were made to sign the consent form. Participants were also informed about the aim of the survey and the benefits, and were assured of how confidentiality of research was to be maintained, Lastly, COVID-19 SOPs were strictly observed

3.8: Dissemination

The study findings will be disseminated through presentations at academic conferences or training using PowerPoint presentations or posters. In addition, an article on the study findings will also be published in agricultural journal to become a suitable tool for researchers, policymakers and chicken farmers. On the other hand, the Research finding will be made available online on the Gulu University library website with hard copies of the report accessed at the university library.

3.9 Limitations

Limitations for this study arose from the use of survey structured questionnaire for data collection and simple flotation method for examine fecal samples as below.

The structured questionnaire used for data collection was designed in English, yet it was administered to semi-literate respondents. However, the researcher addressed this by using research assisstants who understand both English and local language (Lango) very well.

Additionally, the simple flotation method used to examine fecal samples for worm burden in chickens, did not consider some worms with heavy eggs. This was intended to be considered in further researches as it had no negative effect to this study.

CHAPTER FOUR

RESULTS

4.1 Socio-demographic characteristics of study participants

The results showing the sociodemographic characteristics of respondents are presented in Table 1. The results indicated that a proportion (60%) of farmers were males, with an average age of 42.9 years. Over 80% of chicken farmers interviewed had attained the post-primary level of education. Most respondents (87%) were married, with 60% of them having a household size of more than five people. Most respondents had an average monthly household income of 565,383.3 Uganda shillings. With regard to chicken keeping, results showed that chicken farmers had an average farmland size of 0.78 acres allocated to chicken keeping. Most chicken farmers (53%) were mainly practicing extensive methods of chicken keeping, and mostly (56%) rearing local breeds of chicken. The results also showed that chicken farmers in Lira City had on average eight years of chicken farming experience. Farmers were currently rearing, on average, 202 chickens, with a previous annual chicken population of 2,651 birds. Interestingly, chicken farmers employed one worker on their farms.

***Table 1**: The sociodemographic characteristics of study participants*

Variables		**Frequencies and Means**	
Categorical Variables		**No. of respondents (n = 180)**	**Percentage (%)**
Sex	Female	72	40
	Male	108	60
Education level	Informal	5	3
	Primary	25	14
	Secondary	76	42
	Tertiary	74	41
Marital status	Single	15	8
	Married	157	87
	Widowed	8	4
Household size	1 - 3 people	13	7
	4-5 people	59	33
	>5 people	108	60
Chicken Breed	Local chicken	100	56
	Exotic chicken	37	21
	Improved chicken	43	24
Rearing Method	Extensive	96	53
	Semi-intensive	46	26
	Intensive	38	21
Continuous Variables		**Mean**	**Standard Error of Mean**
Age		42.9	11.3
Household monthly income (UGX)		565,383.3	38,052.5
Land size		0.8	0.1
Chicken farming experience		7.6	0.7
Current Bird Population		202	28
Annual Bird Population		2651	876
Number of Employees		1	1

***Note**: UGX = Uganda Shillings*
Source: *Primary Data, 2024*

A proportion (63%) of chicken farmers had not received training on biosecurity measures (Figure 4).

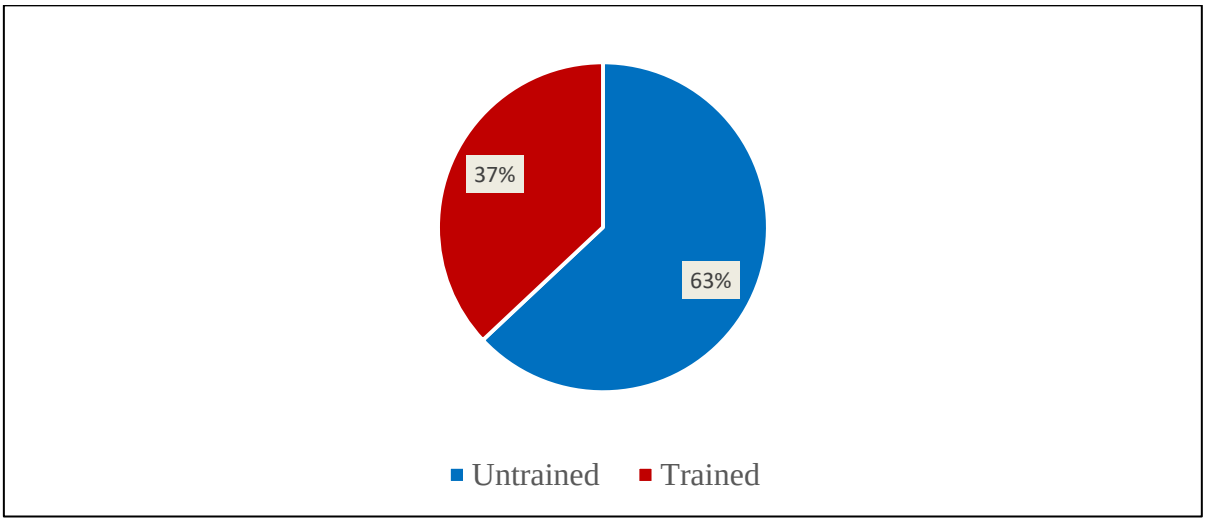


***Figure 4:** Proportion of chicken farmers who had received training on biosecurity measures*

The majority (77%) of chicken workers or employees had not received any training on biosecurity measures (Figure 5).

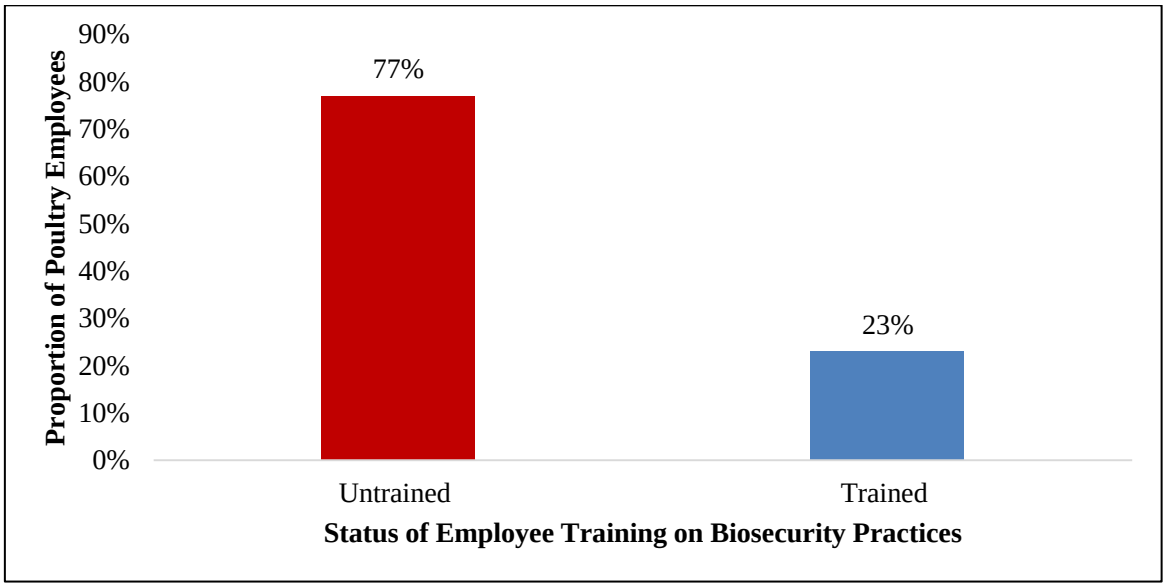


Figure 5: *Proportion of workers on the chicken farm who had received training on biosecurity measures*

4.2 The common chicken diseases, chicken disease symptoms, and intestinal worms burden across different farms

Results on the common chicken diseases, chicken disease symptoms, and intestinal worm burden across different farms are presented in Tables 2, 3, and 4, respectively.

Results indicated that most chicken farmers (80%) registered Coccidiosis disease in their farms (Table 2). Just over half of the farms surveyed (54%) registered Newcastle disease infection in their birds. Most farmers (60%) did not register Fowl coryza disease in their farms. Similarly, the results indicated that a significant proportion of farmers (65%) did not register Infectious bronchitis disease. Additionally, most farmers (87%) did not register Gomboro (Infectious bursal disease). Results also indicated that most farmers took more than a month to either record any morbidity (33%) or mortality (41%).

***Table 2**: The presence of chicken diseases across different chicken farms*

Disease		Frequency (n=180)	Percentage (%)
Coccidiosis	No	36	20
	Yes	144	80
Newcastle disease	No	82	46
	Yes	98	54
Fowl coryza	No	108	60
	Yes	72	40
Infectious bronchitis (cough)	No	117	65
	Yes	63	35
Gomboro (Infectious bursal disease)	No	156	87
	Yes	24	13
Frequency of morbidity occurrence	At least once a week	31	18
	Once every two weeks	38	21
	Once a month	51	28
	> one month	60	33
Frequency of mortality occurrence	At least once a week	26	14
	Once every two weeks	34	19
	Once a month	47	26
	> one month	73	41
Continuous Variables		**Mean**	**Std**
Monthly morbidities		8.04	9.18
Annual morbidities		40.21	43.36
Monthly mortalities		8.54	11.42
Annual mortalities		39.84	75.53

***Note:** Std = Standard deviation.*
Source: *Primary Data, 2024*

The results indicated that the most common symptoms observed by the farmers were loss of appetite (83%), general body weakness (73%), and whitish or greenish diarrhea (79%) (Table 3). Results also showed that other symptoms noticed by chicken farmers were dropping of wings (51%), loss of weight (47%), rough feathers (44%), swollen head (26%), difficulty breathing (22%), and coughing (21%).

Table 3: *Chicken Disease Symptoms registered in chicken farms*

Symptom		Frequency (n = 180)	Percentage (%)
Dropping wings	No	89	49
	Yes	91	51
Loss of appetite	No	30	17
	Yes	149	83
Difficulty in breathing	No	141	78
	Yes	39	22
Rough feathers	No	101	56
	Yes	79	44
Emaciation (loss of weight)	No	95	53
	Yes	85	47
Coughing	No	142	79
	Yes	38	21
General body weakness	No	49	27
	Yes	131	73
Swollen head (eyes, comb, and wattle)	No	134	74
	Yes	46	26
Whitish/ Greenish diarrhea	No	37	21
	Yes	143	79

Source: *Primary Data, 2024*

The results on worm burden indicated the highest (23.3%) prevalence of intestinal worms in intensive chicken farming management systems (Table 4). Results also showed high (23.3%) prevalence of *Ascarida galli* in intensive farming, while Capillaria species (16.7%) is highly prevalent in semi-intensive farming system.

Table 4: *The prevalence of intestinal worms across different chicken farming systems*

Intestinal Worm Attributes		Farming Systems						χ^2	p - value
		Intensive		Semi-Intensive		Extensive			
		n=30	%	n=30	%	n=30	%		
Prevalence	Negative (-)	18	60	21	70	18	60	0.861	0.650
	Positive (+)	12	40	9	30	12	40		
Species	*Ascaridia galli*	7	23.3	2	6.7	0	0	23.11	0.001
	Capilliaria ssp	0	0	5	16.7	2	6.7		
	Heterakis gallinarium	0	0	2	6.7	3	10		

Source: *Primary Data, 2024*

4.3 The extent of use of biosecurity practices by smallholder and commercial chicken farmers

4.3.1 Forms of biosecurity measures implemented at chicken farms in Lira City

The different forms of biosecurity measures implemented by different farmers in various chicken farms are presented in Tables 5 and 6.

Results indicated that most (72%) did not clean the chicken house and equipment (Table 5). In the same vein, a proportion (72%) of chicken farmers did not disinfect the chicken house and associated equipment used in rearing chicken. With regard to the isolation of birds, most farmers and their employees (75%) did not isolate the sick nor the new birds from the healthy and old stock of chicken, respectively. Most chicken farmers (84%) did not restrict visitors or other intruders from accessing the chicken premises. Furthermore, the majority of chicken farmers (73%) reported that they did not vaccinate their birds. The results also showed that most chicken farmers and their employees (90%) did not manage litter and waste on their farms. Results also indicated that most farms (75%) were not practicing clean feeding and watering as a biosecurity measure.

Table 5*: Different forms of Biosecurity measures implemented at chicken farms*

Biosecurity Measures Used		**Frequency (n = 180)**	**Percentage (%)**
House & Equipment cleaning	No	129	72
	Yes	51	28
House & Equipment disinfection	No	130	72
	Yes	50	28
Isolating sick & new birds	No	135	75
	Yes	45	25
Visitor & Intruder restriction	No	151	84
	Yes	29	16
Vaccination	No	132	73
	Yes	48	27
Litter management	No	162	90
	Yes	18	10
Clean feeding & watering	No	135	75
	Yes	45	25

Source: *Primary Data, 2024*

In Table 6, the results indicated that most chicken farms (62%) did not have fences and gates. Results further showed that a proportion of farms (82%) did not have functional footbaths installed at their chicken farm premises. The results also showed that in most farms (76%), there was no visitors' logbook. Results also indicated that most farms (65%) did not feed their chicken outside the established chicken houses. The results further showed that special clothes and footwear were not used in 79% and 63% of chicken farms observed, respectively. It also indicated that the majority (92%) of chicken farms in Lira city did not have special clothing and footwear for their farm visitors. Results showed that in more than 90% of chicken farms, visitors and farm workers did not shower while going in and coming out of the chicken premises, and almost half (47%) of chicken farms had isolation rooms for diseased chickens.

Table 6: *Biosecurity measures observed or seen at chicken farms during data collection*

Biosecurity Measure		**Frequency (n = 180)**	**Percentage (%)**
Fence & Gate	No	112	62
	Yes	68	38
Functional Footbath	No	148	82
	Yes	32	18
Visitor's book availabe	No	137	76
	Yes	43	24
No feeding of chicken outside	No	63	35
	Yes	117	65
Use of Special Cloth	No	142	79
	Yes	38	21
Use of Special Footwear	No	113	63
	Yes	67	37
Shower in and out of the Chicken House	No	164	91
	Yes	16	9
Visitors Wear Special Clothes & Footwear	No	165	92
	Yes	15	8
Biosecurity Signage at the Farm	No	163	91
	Yes	17	9
Isolation Room for Diseased Chicken	No	96	53
	Yes	84	47

Source: *Primary Data, 2024*

4.3.2 Extent of use of cleaning and disinfection as a biosecurity practice by smallholder and commercial chicken farmers

The results showing the extent of the use of cleaning biosecurity measures for disease prevention in different farms in Lira city are presented in Table 7. Results indicated that chicken farmers sometimes fumigated chicken houses before new birds were introduced (Mean Score = 2.67). Chicken farmers sometimes washed their hands before and after entering the chicken houses (Mean Score = 2.72). The addition of disinfectants to water in the footbath (Mean Score = 2.03), workers putting on special clothing and footwear before entering the chicken house (Mean Score = 1.99), and disinfection of feeding troughs, equipment, and chicken house (Mean Score = 3.26) were rarely practiced cleaning biosecurity measures across farms in Lira City. The results further indicated that the daily cleaning of feeding and drinking troughs, tools, and equipment (Mean Score = 4.22) was frequently done on farms. Similarly, not using of dirty water, such as that from washing clothes for cleaning the chicken house (Mean Score = 3.88), was frequently done. Overall, the results indicate that cleaning as a biosecurity measure for disease prevention was sometimes practiced by chicken farms (CAS = 3.16).

Table 7: *The extent to which different cleaning biosecurity measures are used in different farms*

Scale Item	Mean	Std	Decision
Fumigating the chicken house before new birds are brought in	2.67	1.63	Sometimes
Washing of hands before and after entering the chicken house	2.72	1.48	Sometimes
Adding disinfectant to the water in the footbath	2.03	1.46	Rarely
Disinfecting the feeding troughs, equipment, and chicken house	3.26	1.21	Rarely
Cleaning of feeding and drinking troughs, tools, and equipment daily	4.22	1.00	Frequently
Not using of dirty water (e.g., from washing clothes) to clean the chicken house	3.88	1.37	Frequently
Composite average score (CAS)	3.13	1.36	Sometimes

Note: *Decisions made based on 5-point Mean score ranges of 1 – 1.80 for Never, 1.81 – 2.61 for Rarely, 2.62 – 3.42 for Sometimes, 3.43 – 4.23 for Frequently, and 4.24 – 5.04 for Every day (Alkharusi, 2022; Harpe, 2015).*

Source: *Primary Data, 2024*

4.3.3 Extent of use of traffic control as a biosecurity practice by smallholder and commercial chicken farmers

The results showing the extent of the use of traffic control as a biosecurity measure are presented in Table 8. The results indicated that chicken farms frequently did not keep other animals in the chicken farm (Mean Score = 3.52). It is also shown that chicken farmers sometimes (Mean Score = 3.29) did not allow the chickens on their farms to mingle with other local and wild birds. Additionally, the results showed that wild birds frequently (Mean Score = 3.43) did not access stored feed across chicken farms in Lira City (Table 8). Results also indicated that the number of birds in the chicken houses frequently did not exceed the house's carrying capacity (Mean Score = 3.87). Results, therefore, clearly indicated that the overall animal traffic control measures were frequently (CAS = 3.03) practiced across chicken farms in Lira city.

On the other hand, results showed that the number of people on the chicken farms at any given time was rarely restricted across farms in Lira City (Mean Score = 2.60). Both the prohibition of vehicles (Mean Score =1.70) and keeping records of all farm visitors (MS = 1.78) were never practiced across chicken farms in Lira city. Results showed that human traffic control measures were rarely practiced in chicken farms. However, results generally indicated that the traffic control measures were sometimes implemented at chicken farms in Lira city (CAS = 2.89), with animal traffic control measures (RII = 0.61) being practiced than human traffic control measures (RII = 0.56).

Table 8: *Results on the extent to which different traffic control biosecurity measures are used*

F	Scale Item	Mean	Std	Decision	RII
1	Other animals are not reared on the chicken farm	3.52	1.62	Frequently	0.6
	Chickens on the farm do not mingle with other local and wild birds	3.29	1.65	Sometimes	1
	Wild birds do not access stored feeds	3.43	1.48	Frequently	
	The number of birds in the chicken house does not exceeds its capacity	3.87	1.51	Frequently	
	CAS	3.52	0.99	Frequently	
2	Restricting the number of people on the chicken farm at any given time	2.60	1.74	Rarely	0.5 6
	Prohibiting vehicles from entering the farm	1.70	1.56	Never	
	Keeping a record of all farm visitors	1.78	1.29	Never	
	CAS	2.03	1.08	Rarely	
Overall CAS for traffic control		2.89	0.96	Sometimes	

Note: *F1 – animal traffic control measures, F2 – Human traffic control measures, Std = Standard Deviation, CAS = Composite Average Score, RII = Relative Importance Index (Obtained from CAS/5). Decisions made based on 5-point Mean score ranges of 1 – 1.80 for Never, 1.81 – 2.61 for Rarely, 2.62 – 3.42 for Sometimes, 3.43 – 4.23 for Frequently, and 4.24 – 5.04 for Every day (Alkharusi, 2022; Harpe, 2015).*

Source: *Primary Data, 2024*

4.3.4 Extent of use of isolation and quarantine measures as a biosecurity practice by smallholder and commercial chicken farmers

The results showing the extent of use of isolation and quarantine as a biosecurity measure are presented in Table 9. The results showed that chicken farmers sometimes separated sick birds from healthy birds (Mean Score = 2.92) and Kept birds of different ages in separate houses (Mean Score = 2.60) were rarely practiced across farms in Lira City. It is also important to note that isolation and quarantine measures such as examining flock for diseases (Mean Score = 3.24), quarantining birds return from the market (Mean Score = 3.17), and quarantining new birds bought from the market for at least two weeks (Mean Score = 2.83) were sometimes practiced in chicken farms located in Lira City. Hence, overall, it is apparent from the results that chicken farms sometimes practiced isolation and quarantine biosecurity measures in their farms (CAS = 2.88).

Table 9: *The extent to which different isolation & quarantine biosecurity measures are used in different farms*

Scale Items	Mean	Std	Decision
Separating sick chicken from healthy ones	2.92	1.77	Sometimes
Keeping birds of different ages in separate houses	2.60	1.78	Rarely
Quarantine unsold chicken returned from market	3.17	1.23	Sometimes
Quarantine new chicken bought from the market for at least 2 weeks	2.83	4.23	Sometimes
CAS	2.88	2.25	Sometimes

Note: *Std = Standard Deviation, CAS = Composite Average Score. Decisions made based on 5-point Mean score ranges of 1 – 1.80 for Never, 1.81 – 2.61 for Rarely, 2.62 – 3.42 for Sometimes, 3.43 – 4.23 for Frequently, and 4.24 – 5.04 for Every day (Alkharusi, 2022; Harpe, 2015).*

Source: *Primary Data, 2024*

Cleaning was the most used biosecurity measure (RII = 0.632) while Isolation was the least used biosecurity measure practiced by chicken farms in Lira City (Table 10). The results also indicated that there were differences in the application of biosecurity measures across farming systems, with these practices being commonly implemented in intensive farming systems than in extensive farming systems.

Table 10*: The extent of use of different biosecurity measures across different farming systems*

Biosecurity Measure	Overall			Farming System						p-value
				Intensive		Semi-intensive		Extensive		
	Mean	Std	RII	Mean	Std	Mean	Std	Mean	Std	
Cleaning	3.13	1.36	0.63	4.43	0.47	3.65	0.96	2.63	0.72	< 0.001
Traffic control	2.89	0.96	0.58	3.73	0.77	3.40	0.97	2.32	0.63	< 0.001
Isolation	2.88	2.25	0.54	4.65	1.63	3.34	0.99	2.26	0.65	< 0.001
CAS	2.97	1.73		4.23	0.68	3.46	0.92	2.40	0.47	< 0.001

Note: *Std = Standard Deviation, CAS = Composite Average Score, RII = Relative Importance Index. Decisions made based on 5-point Mean score ranges of 1 – 1.80 for Never, 1.81 – 2.61 for Rarely, 2.62 – 3.42 for Sometimes, 3.43 – 4.23 for Frequently, and 4.24 – 5.04 for Every day (Alkharusi, 2022; Harpe, 2015).*

Source: *Primary Data, 2024*

4.4 The effects of biosecurity measures on chicken health

4.4.1 The effect of biosecurity practices on monthly and annual chicken morbidities

The results of the association between the extent of the use of biosecurity measures and chicken monthly and annual morbidities are presented in Table 11. Based on the zero-order correlations (1st model), the results indicated that only the extent of use of cleaning biosecurity measures ($r = 0.162$, $p < 0.05$) had a significant but weak positive correlation with monthly chicken morbidities. However, an inspection of the second model in which confounding variables such as monthly income, age of the chicken farmer, chicken farming experience, land size, present stock, previous annual stock, and the number of workers employed, the results showed that none of the biosecurity measures had a significant association with chicken morbidities.

***Table 11**: Association between biosecurity measures and chicken monthly and annual morbidities*

Model	Biosecurity Measure		Morbidities	
			Monthly	Annual
1	Cleaning		**0.162***	0.122
	Isolation		0.14	0.099
	Traffic control	People	0.007	0.077
		Animal	-0.044	0.015
		Overall	-0.024	0.043
	Overall biosecurity		0.071	0.093
2	Cleaning		-0.054	-0.184
	Isolation		-0.078	-0.072
	Traffic control	People	-0.151	-0.044
		Animal	-0.147	-0.106
		Overall	-0.172	-0.083
	Overall biosecurity		-0.136	-0.147

***Note:** *Correlation is significant at the 0.05 level (2-tailed). Confounding variables controlled include monthly income, age of the chicken farmer, chicken farming experience, land size, present stock, previous annual stock, and the number of workers employed.*

Source: *Primary Data, 2024*

The results of further assessment of the impact of the extent of the use of biosecurity measures on chicken mortalities using hierarchical multiple linear regression are presented in

Table 12. The results indicated that the first step which included likely confounding variables such as monthly income, age of the chicken farmer, chicken farming experience, land size, present stock, previous annual stock, and the number of workers employed. Then the model for assessing the rate of monthly morbidities explained 29.2% of the variation in monthly chicken morbidities, while that for assessing the variations in annual chicken morbidities explained 35.3% of the variation in annual chicken morbidities. When biosecurity measures such as cleaning, isolation and traffic control measures were added to the models in the second step, the total variations in monthly and annual chicken morbidities explained by the model were 35.1% [R squared change = 0.059, F change (9, 39) = 2.341, p = 0.032], and 45.1% [R squared change = 0.098, F change (9, 43) = 3.930, p = 0.001] respectively. The biosecurity measures considered, therefore, explained only an additional 5.9% and 9.8 % of the variations in monthly and annual chicken morbidities, respectively. Importantly, none of the biosecurity measures had a significant effect on monthly chicken morbidities. Only the number of birds currently kept, that is, the present stock (β = -0.540, p = 0.011), had a significant effect on monthly chicken morbidities. On the other hand, the cleaning biosecurity measures had a significant negative effect on annual chicken morbidities (β = -0.298, p =0.012). However, amongst all confounding factors included in the models, farmland size (β = 0.506, p = 0.018) and the number of birds currently kept (present stock) (β = 0.535, p = 0.009) had a positive significant effect on annual chicken morbidities, with the present stock having the highest significant effect on annual chicken morbidities (β = 0.535, p =0.009).

Table 12: *The effect of biosecurity measures on chicken monthly and annual morbidities*

Step	Variables	Monthly Morbidities			Annual Morbidities		
		β	**S.E**	**p-value**	**β**	**S. E**	**p-value**
1	Constant	-1.164	1.091	0.292	-0.669	1.095	0.544
	Monthly Income	0.195	0.193	0.319	0.216	0.194	0.271
	Experience	-0.257	0.198	0.2	-0.377	0.195	0.06
	Land Size	0.32	0.213	0.139	0.583	0.211	0.008
	Present Stock	0.43	0.189	0.028	0.392	0.191	0.046
	Previous Stock	0.035	0.111	0.751	0.137	0.111	0.222
	Employee Size	-0.185	0.304	0.547	-0.128	0.308	0.68
2	Constant	-0.462	1.149	0.69	-0.078	1.097	0.943
	Monthly Income	0.145	0.197	0.465	0.152	0.187	0.421
	Experience	-0.28	0.203	0.175	-0.296	0.193	0.133
	Land Size	0.233	0.217	0.29	0.506	0.206	0.018
	Present Stock	0.54	0.201	0.011	0.535	0.194	0.009
	Previous Stock	0.073	0.114	0.527	0.125	0.11	0.263
	Employee Size	-0.042	0.329	0.899	0.019	0.315	0.953
	Cleaning measures	-0.174	0.122	0.162	-0.298	0.113	0.012
	Isolation measures	-0.034	0.051	0.509	0.024	0.049	0.624
	Traffic control	0.001	0.103	0.993	0.133	0.087	0.133
Model Fit	Step 1	*R^2 = 0.351, R^2 change = 0.059, F change (9, 39) = 2.341, p = 0.032*					
	Step 2	*R^2 = 0.451, R^2 change = 0.098, F change (9, 43) = 3.930, p = 0.001*					

Source: *Primary Data, 2024*

4.4.2 The effect of biosecurity practices on monthly and annual chicken mortalities

The results that show the association between the extent of the use of biosecurity measures and chicken monthly and annual mortalities are presented in Table 13. In the first model without confounders, it is apparent that both the extent of use of cleaning ($r = -1.65$, $p < 0.05$) and isolation ($r = -0.244$, $p < 0.05$) biosafety measures had a significant negative association with monthly chicken mortalities. Upon controlling for the likely confounding factors such as monthly income, age of the chicken farmer, chicken farming experience, land size, present stock, previous annual stock, and the number of workers employed, the results indicate that only the extent of use of cleaning ($r = -0.315$, $p < 0.05$) and extent of use of all biosecurity measures ($r = -0.298$, $p < 0.05$) had weak associations with the rate of annual chicken mortalities recorded at the farm.

Table 13: *The association between biosecurity measures and chicken monthly and annual mortalities*

Model	**Biosecurity Measure**		**Mortalities**	
			Monthly	Annual
1	Cleaning		-0.165*	0.024
	Isolation		-0.244*	0.008
	Traffic control	People	-0.061	-0.023
		Animal	0.034	-0.033
		Overall	-0.018	-0.044
	Overall biosecurity		-0.145	-0.014
2[a]	Cleaning		-0.02	-0.315*
	Isolation		-0.14	-0.192
	Traffic control	People	0.001	-0.109
		Animal	0.109	-0.1
		Overall	0.057	-0.123
	Overall biosecurity		-0.045	-0.298*

Note*: *Correlation is significant at the 0.05 level (2-tailed). a = confounding variables controlled - monthly income, age of the chicken farmer, chicken farming experience, land size, present stock, previous annual stock, and the number of workers employed.*

Source: *Primary Data, 2024*

The results of further assessment of the effect of the extent of the use of biosecurity measures on chicken mortalities using hierarchical multiple linear regression (HMLR) are presented in Table 14. The results of the hierarchical multiple linear regression indicated that the first step which included likely confounding variables such as monthly income, age of the chicken farmer, chicken farming experience, land size, present stock, previous annual stock, and the number of workers employed, the model for assessing the rate of monthly mortalities explained 15.8% of the variation in monthly chicken mortalities respectively, while that for assessing the variations in annual chicken mortalities explained 43.7% of the variation in annual chicken mortalities. When biosecurity measures such as cleaning, isolation and traffic control measures were added to the models in the second step, the total variations in monthly and annual chicken mortalities explained by the model were 21.7% [R squared change = 0.059, F change (9, 44) = 1.355, p = 0.238], and 51.3% [R squared change = 0.076, F change (9, 44) = 5.159, $p < 0.001$] respectively.

***Table 14**: The effect of biosecurity measures on chicken monthly and annual mortalities*

Model	Variables	Monthly Mortalities			Annual Mortalities		
		β	***S. E***	**p-value**	**β**	***S. E***	**p-value**
1	Constant	1.055	0.344	0.004	-0.916	0.984	0.357
	Monthly Income	-0.028	0.061	0.648	0.259	0.175	0.146
	Experience	-0.005	0.061	0.931	-0.262	0.174	0.139
	Land Size	-0.039	0.067	0.562	0.641	0.191	0.002
	Present Stock	-0.084	0.056	0.139	0.418	0.16	0.012
	Previous Annual Stock	-0.015	0.035	0.675	0.074	0.099	0.459
	Employee Size	-0.014	0.093	0.884	0.209	0.266	0.435
2	Constant	1.078	0.36	0.004	-0.191	0.993	0.849
	Monthly Income	-0.04	0.062	0.521	0.221	0.171	0.203
	Experience	0	0.063	0.996	-0.272	0.174	0.125
	Land Size	-0.052	0.068	0.448	0.562	0.189	0.005
	Present Stock	-0.096	0.06	0.119	0.585	0.167	0.001
	Previous Annual Stock	-0.024	0.036	0.507	0.115	0.099	0.253
	Employee Size	0.045	0.1	0.654	0.281	0.275	0.312
	Cleaning Measures	0.006	0.038	0.87	-0.246	0.104	0.022
	Isolation Measures	-0.022	0.016	0.185	0.006	0.045	0.895
	Traffic Control	0.039	0.029	0.183	-0.023	0.08	0.778
Model Fit- Step 1	Monthly mortalities	$R^2 = 0.158$					
	Annual mortalities	$R^2 = 0.437$					
Model Fit - Step 2	Monthly mortalities	$R^2 = 0.217$, R^2 change = 0.059, F change (9, 44) = 1.355, p = 0.238					
	Annual mortalities	$R^2 = 0.513$, R^2 change = 0.076, F change (9, 44) = 5.159, p < 0.001					

***Note**: **β** – Beta value. **S.E.** – Standard Error*

Source: *Primary Data, 2024*

The results show that the biosecurity measures explained only 5.9% and 7.6% of the variations in monthly and annual chicken mortalities, respectively. Importantly, in the final model, the results indicate that biosecurity measures did not have a significant effect on monthly chicken mortalities. On the other hand, the results reveal that only cleaning biosecurity measures had a significant negative effect on annual chicken mortalities (β = -0.246, p = 0.022). Among the confounding factors included in the models, the results show that farmland size (β = 0.562, p = 0.005) and the number of birds currently kept (present stock) (β = 0.585, p = 0.001) had a positive and significant effect on annual chicken mortalities.

4.4.3 The effect of biosecurity practices on worm prevalence

The results showing the effect of biosecurity practices on worm prevalence are presented in Table 15.

Table 15: *Effects of biosecurity practices on worm prevalence (burden)*

Variables	**β (*S.E*).**	**t-value**	**p-value**	**OR/ (*S.E*)**
Monthly Income	1.121 (0.564)	1.99	0.047	0.407 (0.201)
Land Size	1.258 (0.481)	2.61	0.009	0.456 (0.172)
Present Stock	- 0.532 (0.469)	-1.14	0.256	- 0.193 (0.170)
Sex	0.871 (0.317)	2.75	0.006	0.307 (0.105)
Age	- 0.01 (0.011)	-0.86	0.39	- 0.004 (0.004)
Isolation Bio-measures	0.477 (0.219)	2.18	0.029	0.173 (0.079)
Constant	- 6.827 (3.083)	-2.21	0.027	
Pseudo R-squared	0.200	Number of observations		90
Chi-square (χ^2)	23.696	Probability of χ^2		0.001
Akaike crit. (AIC)	108.593	Bayesian crit. (BIC)		126.091

Note: **β** *– Beta value.* ***S.E.*** *– Standard Error,* ***OR*** *– Odds Ratio*

Source: *Primary Data, 2024*

The results showed that biosecurity measures, precisely isolation biosecurity measures (OR = 0.173, p = 0.029), had a positive effect on worm prevalence, with isolation practices leading to a 17.3% likelihood of worm prevalence. It was also evident that other attributes such as monthly income (OR = 0.407, p = 0.047), land size (OR = 0.456, p = 0.009) and sex of the chicken owner, particularly being male (OR = 0.307, p = 0.006), had a positive effect on worm prevalence.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Introduction

This study sought to ascertain the extent to which different biosecurity measures were used and applied in chicken farms in Lira city, as well as to determine the effect of biosecurity measures on chicken health across different farming systems. The findings of this study are therefore discussed in the subsequent sections.

5.2 Social demographic characteristics of farmers

The socioeconomic and operational dynamics of any farming engagement are vital for its productivity and profitability. Based on this, the socioeconomic and operational dynamics of chicken farming in Lira City are discussed below.

The observation that males dominated chicken farming could be due to existing cultural norms in which men dominate control of land, capital, and other factors of production. This contradicts findings by Bukachi *et al.* (2023), who indicate that women are directly involved in the ownership and management of day-to-day small-scale poultry production activities. The disparity in gender ownership of chicken farms can also be linked to limited access to extension and training that enable women to establish and operate their chicken farms. Gender-sensitive programs such as targeted training and access to credit should be established to empower women to engage in chicken farming.

The observation that most chicken farmers were middle-aged, married with sizeable family sizes can be linked to the fact that middle-aged, married farmers are likely more established, with family labor supporting farm operations. Established large households are critical in

reducing production costs, given that they often provide unpaid labor during tasks such as feeding and disease management.

The observation that most chicken farmers attained at least a primary level of education can be linked to existing government universal primary and secondary education programs. Such higher education levels may encourage the adoption of modern practices, including but not limited to biosecurity and feed mixing, among others. This is because high literacy levels improve farm productivity.

The observed average monthly earnings of chicken farmers could be because chicken farming is treated as a supplementary source of income. This implies that its proceeds only boost food security, rather than providing full livelihoods. Chatterjee *et al.* (2022) also note that poultry income is critical for diversifying rural livelihoods but rarely replaces primary income sources.

The finding that most chicken farmers had approximately an acre of land as an average farmland could be due to limited land availability in resource-poor settings. This necessitates low-input systems instead of extensive methods like free-range and low-density chicken farming systems. This observation further explains the finding that most chicken farmers in Lira City practiced extensive methods. Satapathy *et al*. (2017) and Adom *et al.* (2023) also note that a one-acre-sized small-scale chicken farming system can support over 1000 birds.

The observation that there was an average of one worker per farm in chicken farms in Lira City could be explained by the reliance of chicken farmers on family labour. This is mainly aimed at reducing the costs of production, which is critical in low-margin chicken farming systems. This is synonymous with findings by (Lowder et al., 2025) and Abokyi *et al*. (2020)**,** who noted that smallholder farmers tend to reduce operational costs by minimizing paid

labor. This is always attained by either using family labor or joining cooperatives to pool labor for heavy tasks like processing and marketing.

5.3 Extent of use of different biosecurity measures

5.3.1 Extent of use of cleaning and disinfection biosecurity measures

Disinfection of chicken houses before introducing new birds was not always practiced by chicken farmers, probably because farmers did not fully understand the significance of disinfection or they lacked the resources to carry it out consistently. This could also be attributed to limited awareness of the importance of controlling pathogens that might persist in the environment from previous flocks. The results of this study are consistent with findings of Waktole *et al*. (2023) and Sharma (2010), who showed that small-scale chicken farmers hardly fumigated or disinfected chicken houses before introducing new birds. Such inconsistencies in adherence to disinfection as a biosecurity practice potentially lead to outbreaks of chicken diseases, which devastate flocks and result in significant economic losses for farmers. These losses subsequently reduce household income and food security, more so among households in which chicken farming is a primary source of livelihood.

Similarly, the practice of handwashing before and after entering chicken houses was not always practiced by chicken farmers due to a lack of strict routines, limited access to hand-washing facilities, and inadequate training on the importance of hand hygiene in preventing disease transmission between humans and chickens. This agrees with Ssempijja (2019), Tilli *et al*. (2022), and Islam *et al*. (2024), who reported that limited resources and training on proper sanitary practices in chicken farming were some of the drivers of poor biosecurity practices. However, the current findings contradict those of Imam *et al*. (2021), Lambrou *et al*. (2020), and Odo *et al*. (2015), who reported that farmers consistently adhered to, and frequently practiced, on their farms. Thus, given that handwashing is one of the critical

biosecurity measures that need to be followed, failure to consistently adhere to this biosecurity measure can lead to frequent disease outbreaks, which in turn may lead to the overuse or misuse of antibiotics in chicken production. This can contribute to the development of antimicrobial resistance, posing a significant public health risk. Several studies also emphasized that poor hygienic practices increased the risks of antimicrobial resistance in farming establishments (Abreu *et al*., 2023; Manyi-Loh *et al*., 2018; Hussein *et al*., 2023).

The rare use of disinfectants in footbaths and the infrequent use of special clothing and footwear reveal existing gaps in adherence to biosecurity protocols. This low adherence to these practices could be due to cost constraints, lack of awareness, and the perception that such measures are unnecessary or overly burdensome during chicken-keeping activities. These observations in the present study align with findings of Lambrou *et al*. (2020) and Odo *et al*. (2015), who asserted that the majority of chicken farmers hardly install footbaths let alone use disinfectants in them. Since footbaths are the most essential biosecurity component in preventing the spread of pathogens into and out of chicken houses, failure to regularly use them not only increases the risk of disease outbreak among chicken birds but also the potential to incur gross losses due to cross-contamination.

The fact that chicken farmers rarely disinfect their feeding troughs, equipment, and chicken houses is an indication that, despite disinfection practices not being entirely neglected, they are not thoroughly applied. This inconsistency might arise from a lack of training on proper disinfection techniques and the associated high cost of disinfectants, leading farmers to skip or minimize these steps. Delpont *et al*. (2021) and Siekkinen *et al*. (2012) also adduced that the high costs attributable to purchasing disinfectants were some of the barriers hindering the adoption of biosecurity measures in chicken farms.

Chicken farmers always adhered to daily cleaning of feeding and drinking troughs because they recognized the significance of keeping feeding and drinking areas clean to enhance the health and productivity of their chickens. In agreement with this result, Abiri *et al*. (2023) emphasized that the use of clean farm tools was essential in the prevention of diseases, as well as increasing productivity. The adherence to daily cleaning of feeding troughs provides a positive outlook on chicken keeping since it reflects good hygiene practices that can prevent the buildup of harmful pathogens.

The result that cleaning practices were not always implemented as biosecurity measures can be explained by the fact that despite smallholder chicken farmers having a general awareness of the significance of this practice, they are mostly inconsistent in the application of cleaning biosecurity protocols. This inconsistency could be attributed to varying levels of knowledge, resource constraints, and the perceived importance of different practices. This finding is consistent with findings of Waktole *et al*. (2023), who found that chicken farmers hardly adhered to cleaning practices such as washing hands, provision of clean water, and routine cleaning of feeding troughs, as they recorded prevalence rates below the global average. On the other hand, the present findings contradict those of Ismael *et al*. (2021) and Scott *et al*. (2018), who reported that biosecurity measures, especially the use of footbaths was regularly practiced by chicken farmers. This is an indication that while farmers may understand the importance of basic hygiene practices, they often neglect more specialized or resource-intensive practices. This is particularly concerning the smallholder chicken farmers with high human-chicken interactions, since neglecting such critical biosecurity measures can increase the risk of zoonotic diseases, where pathogens can be transmitted from chicken to humans and vice versa.

5.3.2 Extent of use of traffic control as a biosecurity practice by smallholder and commercial chicken farmers

The observation that chicken farmers frequently kept other animals within the chicken farm could be explained by the limited land available to them to conduct chicken farming practices. This is supported by the finding that chicken farmers had less than one acre of land allocated for chicken farming activities. This practice can also be explained by chicken farmers' efforts to diversify their on-farm income sources. This practice, however, poses serious biosecurity risks, more so the risk of zoonotic disease transmission between chicken birds and other animals kept in the farm. Otte *et al*. (2007) and Ssematimba *et al.* (2013) also reveal that keeping other animals in chicken farms may elevate the risk of contamination and therefore compromise biosecurity, as other animals can act as vectors for pathogens. Keeping other animals in the same premises as chicken birds may also result in interspecific interactions, which may lead to the emergence of new infections, hence escalating disease risks. These findings in this study are synonymous with those by Otte *et al.* (2007) and Arabi *et al.* (2021), who emphasized that the proximity of other forms of livestock to chicken birds was a major biosecurity breach in farms in Uganda.

Chicken farmers sometimes allowed their chickens to mingle with local and wild birds, which was a great concern since this practice increases the risks of zoonotic diseases, especially pathogenic Newcastle disease and avian influenza, among others, transmission from wild birds to the chicken birds. This is partly attributed to the fact that wild birds often serve as reservoirs and hence carriers of these diseases (Wille & Holmes, 2020). These results corroborate those by Das-Gupta *et al*. (2022), who noted that free-range chicken systems contributed to higher disease outbreaks among chicken birds due to frequent contact between domestic and wild birds. Tago *et al*. (2016) also noted that farmers were more inclined to

control animal movement than human activity, given that animals are perceived as the primary disease vectors. Furthermore, the finding that stored feed was frequently accessed by birds across chicken farms presented a notable biosecurity risk since feed contamination is one of the major routes through which pathogens are introduced into the chicken system. Abreu *et al*. (2023) reported that unregulated access to feed stores by birds leads to feed contamination through aspects such as birds' fecal matter or droppings, feathers, and dirt, among other contaminants that may harbor pathogens that lower feed quality. This observation relates to study findings by Lambrou *et al.* (2020) and Odo *et al*. (2015), who highlighted that securing feed stores is essential for the prevention of contamination and hence minimizing disease risk.

The frequent overcrowding of chickens in chicken houses, characterized by holding bird numbers beyond the chicken house's carrying capacity, was equally a serious biosecurity issue in the study area. This is because overcrowding increases the birds' stress levels, an outcome that not only reduces the birds' immunity but also creates an environment that is conducive to the spread of diseases. According to ISA (2024), overcrowded conditions often impede proper ventilation and sanitation, which escalates biosecurity risks in the farm. Overcrowding in chicken farms is directly associated with increased disease prevalence, attributable to poor hygiene and high stress levels among birds (Msimang *et al.* 2022). Therefore, from these results, the fact that farmers put in place and practiced several animal traffic control measures was an indication that farmers are aware of the risks posed by other animals. However, the observation that most of these practices were occasionally enforced was a sign that farmers did not have the required level of awareness and understanding of the full spectrum of biosecurity animal traffic-related practices needed to protect birds from infections.

Conversely, human traffic control measures such as restriction of the number of people on the farms, prohibition of vehicles, and keeping records of farm visitors were rarely practiced across farms because chicken farm owners and their workers lacked awareness, since most farmers and their workers did not receive any training on the value of restricting human traffic in preventing disease spread among birds. Given that humans are among the primary vectors that facilitate disease transmission in birds, failure to regulate their entry into and out of chicken farm facilities reveals underlying biosecurity gaps, making farms in this region vulnerable to the introduction and reintroduction of diseases from external sources. Lestari *et al*. (2011), Ssematimba *et al.* (2013), and Ssempijja (2019) specifically emphasize that limiting human traffic is essential for maintaining biosecurity. This is because both farm workers and visitors can unknowingly introduce pathogens through contaminated footwear, clothing, and equipment, among other avenues. Additionally, Conan *et al*. (2012), Ritter *et al.* (2017), and Robertson (2020) also note that the poor implementation of human traffic control measures makes farms vulnerable to the introduction of external pathogens. Therefore, the findings of the current study serve as a reminder to us of the critical need for improved biosecurity training and awareness among chicken farmers. Although chicken farmers may recognize why it is important to control animal movement, heightened laxity in controlling human traffic may create gaps through which pathogens are introduced to farms. The observed failure to enforce human traffic practices like the prohibition of vehicle access and maintaining visitors'book further exacerbates the risk of introducing infections to chicken birds.

5.2.3 Extent of use of isolation and quarantine measures as a biosecurity practice by smallholder and commercial chicken farmers

The farmers recorded a relatively low mean score for the separation of sick birds from healthy ones. This is an indication that, whereas farmers acknowledge the importance of isolating infected birds, they are very inconsistent in applying this practice. This can be attributed to limited infrastructural facilities, financial constraints, and even limited awareness of the critical role of isolation in preventing disease spread. This further explains the result that chicken farmers recorded inadequate separation of birds of different ages, as well as the inconsistent isolation of newly acquired birds for two weeks. These results are consistent with findings by Negro-Calduch *et al*. (2013) and Attia *et al*. (2022), who revealed that many small-scale chicken farmers lack the necessary resources, both financial and infrastructural, to fully implement Isolation biosecurity measures. Otieno *et al.* (2023) and Subasinghe *et al.* (2023) also indicated that better access to resources, training, and stricter regulatory frameworks are essential for the consistent application of isolation biosecurity practices in farms. Studies by Delia *et al.* (2024) and FAO (2013) also indicated that chicken farmers do not have the necessary infrastructure to separate birds either by age or health status. The inconsistent application of isolation biosecurity measures in chicken farms in Lira City significantly affects disease control efforts and the productivity of different chicken production systems. It is also essential to note that chicken is one of the major sources of income and nutrition for households; the lack of stringent biosecurity practices increases the risk of disease outbreaks, which could severely impact both the health of chicken and the economic well-being of farmers. Moreover, the inconsistent use of isolation measures can facilitate the spread of contagious diseases, such as Newcastle disease and avian influenza, which often lead to substantial losses in chicken populations.

All in all, the finding that isolation biosecurity measures were less frequently used as compared to cleaning measures can be linked to the fact that cleaning is usually seen as a more accessible and manageable practice for farmers, requiring fewer resources and less technical expertise compared to more complex biosecurity interventions like isolation and movement control. Such dynamics, therefore, imply that farmers prioritize visible cleanliness over other equally critical biosecurity practices. Additionally, the variation in the application of biosecurity measures can be explained by differences in farmers' level of knowledge and awareness among farmers, attributable to the observation that majority of farmers either had informal education, primary or secondary level of education which may not expose them to information on chicken biosecurity approaches, and majority of farmers and their workers had not received any training on the biosecurity practices. It is also important to note that majority of chicken farming practices could be informal and less regulated and therefore biosecurity is treated as an optional measure, unlike the commercial practices in which implementation of biosecurity measures is treated as a mandatory with established frameworks (Mutua & Dione, 2021; Tsegaye *et al*., 2023). This implies that there is a critical need to increase awareness among farmers through the provision of technical support and capacity-building initiatives to empower farmers to consistently and effectively implement biosecurity measures, including isolation and management of human traffic.

5.3 The effects of biosecurity measures on chicken health

5.3.1 The effects of biosecurity measures on chicken morbidities and mortalities

From the present study, the extent of use of cleaning biosecurity measures had a weak, significant positive association with monthly chicken morbidities because farms with higher morbidity rates may increase cleaning measures in response to disease outbreaks. Such reactionary approaches lead to a spurious correlation whereby farms experiencing more

morbidities also demonstrate higher levels of cleaning efforts. These findings are consistent with study findings by Rohr *et al.* (2019) and Wolff *et al*. (2019), who assert that heightened disease prevention efforts usually coincide with heightened disease prevalence due to farmers' reliance on reactive measures rather than proactive disease prevention strategies. Therefore, the observed association between the implementation of cleaning biosecurity protocols and an increase in chicken morbidities and mortalities can serve as a reinforcement for the need for consistent and comprehensive adherence to biosecurity measures.

On the other hand, cleaning biosecurity measures had a significant negative effect on annual chicken mortalities because consistent cleaning may help reduce the accumulation of infectious agents, resulting in reduced morbidities and hence mortalities. These observations in the present study agree with findings by Christensen *et al.* (2021) and Hunter *et al*. (2008), who highlight the significance of regular cleaning in providing a safe farm environment for birds. A study by Delia *et al*. (2024) also identified cleaning as a key factor in controlling pathogenic bacterial and viral infections among chicken birds. The finding that cleaning biosecurity measures reduced the occurrence of monthly chicken mortalities could also be due to the reduction of pathogenic agents by consistent cleaning practices, hence reducing the likelihood of disease transmission and outbreak within chicken flocks. This results in low monthly mortality rates.

However, isolation biosecurity measures, especially the quarantine of newly acquired birds and isolation sick birds, were negatively associated with monthly chicken mortalities because isolation practices reduce disease transmission from new and sick birds to old and healthy birds, respectively. This finding is consistent with observations by Ismael *et al.* (2021) and Msimang *et al.* (2022), who report that effective isolation of infected or new birds prevents disease outbreaks and hence reduces both short-term and long-term mortality rates.

The fact that controlling for confounding effects of attributes like farmer's income, age, stock dynamics and number of workers among others, created no significant association between biosecurity measures and chicken morbidities could be an indication that other external farm management practices, other than biosecurity measures exerted stronger influence on morbidity outcomes, overshadowing the effects of biosecurity practices. This is especially evident from the observations from the multiple hierarchical regressions that biosecurity measures such as cleaning, isolation, and traffic control partially contribute to the variation in morbidities. Such dynamics can be because chicken diseases are often spread via several pathways. This means that focusing on biosecurity measures like cleaning and isolation alone may not be sufficient to effectively disrupt these pathways. This is synonymous with findings by Sims (2015) and Tabashsum *et al.* (2023), who adduce that integrated approaches such as concurrent use of cleaning, vaccination, proper housing, and ventilation, among others, contribute to meaningful reduction of morbidity cases among chicken birds.

Furthermore, the present stock size of chicken farms had a negative association with chicken morbidities can be explained by the fact that larger farms may not only have better access to veterinary services but also institute more structured biosecurity protocols that ensure stronger disease monitoring and surveillance. These findings are consistent with those by Erichsen *et al*. (2024) and Gržinić *et al*. (2023), who revealed that larger farms often have better infrastructure and farm management practices, to greatly lower both morbidity and mortality rates. This implies that whereas larger farms have heightened exposure to disease vectors, the farmers' deliberate efforts to put in place effective biosecurity measures and farm management systems reduce infections and associated mortalities. This can in part be linked to farmers' efforts to maximize chicken farming's economies of scale with regard to disease control and resource allocation.

On the other hand, the revelation from the results that the farm's present stock size positively influenced the annual occurrence of chicken morbidities is because stock sizes pre-determined conditions for the spread of chicken diseases. For instance, larger stock sizes lead to crowding, creating favorable conditions for the transmission of pathogens (Ellwanger *et al.*, 2021; Lorentzen *et al.*, 2022). These findings are also supported by Mramba & Mwantambo (2024) and *Gržinić et al*. (2023) who reveals that larger stock sizes are associated with greater incidence of chicken diseases, attributable to management challenges like insufficient ventilation, increased pathogen loads, insufficient feeding and vaccination regimes, as well as increased levels of pollution.

Additionally, the increase in farm size increased annual chicken morbidities as well as mortalities could be explained by the fact that larger farms expose their birds to diverse environmental stressors, which increases the occurrence of morbidities. This is particularly pronounced in farming systems in which management practices are sub-optimal. These findings are like those by Graham et al. (2008), Meadows et al. (2018), and Soucheray (2024), who show that larger farms have higher rates of infections. Larger farms may also find it challenging to maintain strict biosecurity protocols across large areas. Therefore, the observed significant positive effects of present stock and farmland size on annual mortalities are an indication that commercial chicken keeping operations require robust biosecurity protocols to mitigate increased disease risks. However, chicken farmers ought to adopt balanced integrated management approaches to optimize chicken health outcomes and hence productivity.

5.3.2 Effect of biosecurity measures on worm burden

The finding that a unit increase in isolation biosecurity measures led to a 17.3% likelihood of worm prevalence across chicken farms could be because isolation biosecurity measures were

not properly practiced. This is supported by the finding that chicken farmers hardly disinfected their chicken houses before either introducing new birds or isolating sick birds to their holding places. This implies that, irrespective of its potential to limit the exposure of chicken to natural predators of helminth eggs or larvae, such as insects, and thus concentrates contaminated fecal materials, birds are re-exposed to already contaminated holding spaces. This resultantly increases the likelihood of reinfection in confined isolation spaces.

Additionally, isolation, if not conducted concurrently with proper cleaning and biosecurity practices, has the potential to aggregate eggs of intestinal worms. Ayodeji (2018), Butucel *et al*. (2022), and Chand *et al.* (2023) also assert that the intensive biosecurity measures, specifically isolation, concentrate specific pathogens, including worms, in confined settings. Thus, whereas isolation practices are typically implemented to reduce disease transmission, they may inadvertently create environments conducive to the persistence of helminths. Partial or inconsistent adoption of isolation practices could inadvertently concentrate pathogens within isolated areas, creating hot spots for worm propagation (Rodarte *et al*., 2023)**.** Mihai *et al.* (2022) and Mugambe *et al.* (2022) also noted that the inconsistent application of isolation measures, as well as complementary sanitation protocols, such as routine disinfection or appropriate waste disposal, may fail to interrupt the lifecycle of worms, allowing their persistence and spread.

From this study's findings, it implies that complementary biosecurity measures, such as regular deworming and sanitation practices, should concurrently be used with isolation biosecurity practices to mitigate potential trade-offs of isolation. This is supported by Obioku *et al*. (2013), who in their study revealed that integration of isolation practices with broader hygiene protocols yields better outcomes in reducing worm prevalence. Waage & Mumford (2008) also emphasized that standalone biosecurity measures are often insufficient unless

integrated into comprehensive management systems. Maehira & Spencer (2019) further show that isolation measures combined with frequent deworming and proper litter management effectively reduce worm burdens. Thus, while isolation practices are essential, their efficacy hinges on holistic farm hygiene. These, therefore, require reinforcement through comprehensive strategies encompassing sanitation, deworming schedules, and farmer education.

An increase in monthly income led to an increase in worm prevalence because wealthier farmers are often investing in larger flocks or adopting semi-intensive systems, which are known to increase exposure to worm-infested environments. Such large-scale operations often rely on outdoor grazing systems to reduce feed costs, inadvertently exposing chickens to higher worm burdens through contact with contaminated soil or intermediate hosts. Similar trends have been reported by Mahoro *et al.* (2017), who revealed that high-income farmers favored practices that often compromise parasite control. High-income and large-scale farmers could therefore benefit from subsidized parasite control programs and training to mitigate risks associated with extensive farming systems.

In the same vein, larger landholdings in this study are associated with an increase in worm prevalence because of increased outdoor access and reduced monitoring of chicken birds. Extensive systems also favor free-range practices, which enhance chicken exposure to infective stages of parasites. These findings are consistent with those by Penninah *et al.* (2019) and Kantor *et al.* (2024), who showed that worm prevalence is significantly higher in extensive or semi-extensive farming systems compared to confined systems. Kantor *et al.* (2024) and Msimang *et al.* (2022) also highlighted the risks associated with extensive farming systems and the complex interactions between biosecurity measures and worm prevalence. These findings, however, contradict those by Norton (2022) and Norton *et al.*

(2013), who revealed that larger land sizes provide greater opportunities for rotational grazing, reducing exposure to contaminated environments.

Male ownership of chicken enterprises led to an increase in worm prevalence because male owners may prioritize productivity or enterprise scalability over preventive measures, inadvertently neglecting parasite control. Male chicken owners may also be more likely to engage in certain practices, such as keeping chickens in more confined environments, which inadvertently increases the risk of parasitic infections. Additionally, the gendered disparities in access to extension services or veterinary resources could have led to laxity among men, whilst women potentially adopt more preventive approaches due to a greater focus on household health. This is consistent with findings by Onidje *et al*. (2024) and USAID *et al*. (2023), who revealed that women in agricultural roles tend to adopt meticulous and preventive strategies, including closer flock monitoring and adherence to biosecurity protocols. Dione *et al*. (2020) also reported similar gender-related differences in livestock management practices, emphasizing the need for gender-sensitive approaches in agricultural extension services. This re-emphasizes the existing gender differences in management practices. Gender-responsive policies could empower women with access to resources and decision-making roles, leveraging their preventive management approaches to reduce parasite burdens.

Therefore, in the context of this study, the nature of worm prevalence in chicken farms is multifaceted, often driven by an interplay of biosecurity practices and socioeconomic factors. Effective interventions require not only technical measures but also an understanding of the broader behavioral and systemic contexts in which these farms operate.

CHAPTER SIX

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.1 Summary of findings

The study revealed that the majority (60%) of chicken farmers were males, with an average age of 42.9 years. Most farmers had household sizes of more than five people and had attained the post-primary level of education. The study also found that most chicken farmers (87%) were married and owned an average farmland size of 0.78 acres. Most chicken farmers (53%) were mainly practicing extensive methods of poultry keeping, and mostly (56%) rearing local breeds of chicken.

In addition, the study found out that cleaning and disinfection biosecurity measure was sometimes practiced by chicken farmers, with greater adherence to the daily cleaning of feeding and drinking troughs, tools, and equipment, and the provision of clean drinking water to chickens. Isolation biosecurity was sometimes practiced by chicken farmers. Animal traffic control measures were moderately implemented, while human traffic control measures, such as restricting the number of people entering chicken farms, prohibiting vehicles, and keeping records of farm visitors, were less frequently implemented across chicken farms in Lira city. Hence, human traffic control was more poorly implemented than animal traffic control. Overall, cleaning was the most used biosecurity measure, followed by Traffic control and Isolation.

Finally, cleaning and disinfection biosecurity measures had a significant negative effect on annual chicken morbidities and mortalities, whereas socio-economic attributes - farmland size and the number of birds currently kept (present stock) had a positive significant effect on annual chicken morbidities. Isolation biosecurity measures had a positive effect on worm

prevalence, and also socioeconomic attributes like monthly income, land size, and the sex of the chicken farm owner, particularly being male, had a positive effect on worm prevalence.

6.2 Conclusions

The majority of poultry farmers were married men, most of whom had attained the post-primary level of education. Poultry farmers mainly keep local breeds of chicken and use an extensive system of poultry keeping. Cleaning was the most used biosecurity measure, followed by traffic control and isolation biosecurity measures. There was low adherence to animal traffic control measures as compared to human traffic control measures.

Biosecurity measures contributed to the reduction in chicken mortalities. However, their effectiveness in reducing worm burden, monthly morbidities, and mortalities remains limited in the face of socioeconomic and operational factors like farmland size and present stock size. It is also important to note that the impact and effectiveness of most biosecurity practices in reducing chicken mortalities, including cleaning and isolation, can only be realized in the long term.

6.3 Recommendations

- Farmers should consistently adhere to all biosecurity measures during their chicken farming operations, rather than being selective about which practices to implement. This will ensure a holistic approach to disease prevention.
- Responsible stakeholders in the poultry value chain should prioritize targeted education and training programs for poultry farmers, their workers, and other community members to emphasize the importance of consistent use of biosecurity practices.

- The government should strengthen regulations and policies that facilitate the monitoring of biosecurity practices in farms to enforce consistent implementation of biosecurity measures across poultry farms.
- Chicken farm owners ought to consider socioeconomic and operational factors such as farmland size, gender, monthly income, and stock size during the establishment of their farms to establish targeted but effective biosecurity management strategies for reduced chicken infection and increased chicken productivity.

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APPENDICES

Appendix A: Informed Consent English Version

VERSION 1

Informed consent form

Title of the study: Effect of biosecurity practices on chicken health in Lira city, northern Uganda.

Investigator: Okwany Alex

Institution: Gulu University

Introduction:

My name is Okwany Alex, a student pursuing Master of science in Animal Production and Marketing at Gulu University. I am researching on the **"Effect of biosecurity practices on chicken health in Lira city, northern Uganda. "** The study is disclosed to you in this informed consent, after which any questions you may have are answered. Having decided to participate in the study, you must sign a consent form, which you will be given a copy to keep.

Sponsors of the research:

This study is self-sponsored.

Purpose:

The study will provide information that will guide the development and implementation of policies on chicken production in Lira city, northern Uganda. It will also help in guiding chicken farmers to make informed decisions and take accurate actions in disease management on their chicken farms.

Procedures:

Participation in this study will involve filling in a questionnaire with the research team (principle researcher and the research assistants.

Who will participate in the study?

You have been chosen to participate in this study because you are among the 400 registered commercial chicken farmers whose farms are located in the geographical area of Lira city in Northern Uganda and are responsible for the health and well-being of their chickens.

GULU UNIVERSITY
RESEARCH ETHICS COMMITTEE
APPROVED UNTIL
10 JAN 2025
FACULTY OF MEDICINE
P. O. Box 166, Gulu

Risks/discomforts:

There is no foreseeable risk of harm or discomfort that will arise from your participation in this

study. The only risk or discomfort will be the inconvenience in terms of time spent during the interview.

Benefits:

Chicken farmers will benefit from my immediate advice as I interact with them during the data collection process. Additionally, more benefits will be availed after a report has been compiled by the researcher on which concerned bodies will react appropriately. The research participants will get feedback on the findings and progress of the study. Also, any new information that affects the study participants (including incidental findings) will be made available to research participants.

Confidentiality:

This research is exclusively for academic purposes and is being conducted as a requirement for the completion of my studies. Your identity will not be revealed to any one as we shall only use codes to identify participants. Information obtained will only be accessible by the research team. Soft



copies of the data will be protected by password and hard copy files will be kept under lock and key only accessible and known to the principal investigator.

Alternatives:

Your participation is voluntary and feel free to leave at any time even after starting on the questionnaire.

Cost:

There will be no cost incurred because of participating in this study.

Compensation:

You will be compensated for your participation in the study with a half litre soap.

Questions:

If you have any questions related to the study, or your rights as a research participant, you can contact the principal investigator, Okwany Alex on +256773252928 or via email on alexokwany@gmail.com

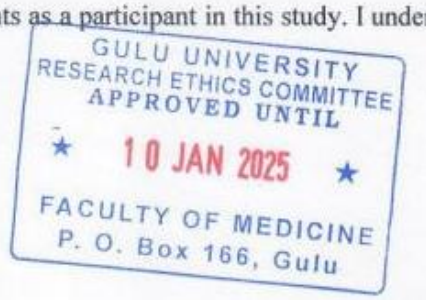
Statement of voluntariness:

Participation in the research study is voluntary and you may join on your own free will. You have a right to withdraw from the study at any time without penalty.

If you have any issues about your rights and participation in the study, please contact the Chairperson, Gulu University Research Ethics Committee, Dr. Gerald Obai Tel: No., 0772305621; email: lekobai@yahoo.com/lekobai@gmail.com; or the Uganda National Council for Science and Technology, on plot 6 Kimera Road, Ntinda, Kampala on Tel 0414705500.

Statement of consent

The research team (research assistant and the principle investigator) has described to me what will be done, the risks, the benefits involved and my rights as a participant in this study. I understand



that my decision to participate in this study will not affect me. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. I will be provided with a copy of this form.

Name .....Signature/thumbprint of participant.....date.....

Name..... Signature of witness.....Date.....

Name.....Signature of interviewer.....Date:.....



Appendix B: Informed Consent Luo Version

TRANSLATED INFORMED CONSENT FORM IN LANGO

Title of the study: EFFECT OF BIOSECURITY PRACTICES ON CHICKEN HEALTH IN LIRA CITY, NORTHERN UGANDA

Nying Atimikweda: OKWANY ALEX

Nying Ka Kwan: GULU UNIVERSITY

Nyute:

Amoti baa,

An nyinga olwongo ni Okwany Alex, atin kwan me Gulu University ite jang gwoko leyi kede cato ame tye ite dul me pur kede kana ame orumu wa. An atye atimo ikweda ikom adwogi atiyo tice agwoko kwoo, ikom yot kom gwen, I Lira city, itumalu me Uganda.

Ikweda man tye me cobo miti me pwonye ame an atye iye ni, konyo opur agwoko gwen imoko tam kede dongo rwom me gwoko gwen malo.

Atyeko yero Yin me bedo ikin jo ame bino miyo agam gi ikom ikweda man, tami obino gwoko imungere ama ngatoro okene pe bino nyang iye. Dong balo man tye me peny yeo ni kace ibino miyo wa agam ikom apeny ame wan obino miyo boti. Dong ibino keto cingi ibalo man me nyutu ni iyee.

Culu pi ikweda man

Ikweda man dul moro pe oculo pire, kono dong ka an ikoma aye atyeko neno ka ni ikweda man tum aber.

Ber ikweda man:

Ikweda man bino konyo jo ame moko tam, odiro, ogwok gwen kede ngec ikom adwogi atiyo tice agwoko kwoo, ikom yot kom gwen,

Jo ame gin bino miyo agam pi ikweda man

Oyero yin me bedo ami agam ikom ikweda man pien yin ibedo agwok gweno ama tye agwoko gweno i Lira city, ikom jo 180 ame obino gamo apeny i bot gi, yin ibedo dano ace lame oyero. Apeny man gamo bino tero cawa amonok keken pi weki cawa me tiyo tic okene.

Tic ame obedo megi ikom ikweda man

Tici ikom ikweda man tye me gamo apeny ame tye ipapara man ame obino miyo boti me aponga.

GULU UNIVERSITY
RESEARCH ETHICS COMMITTEE
APPROVED UNTIL
★ 10 JAN 2025 ★
FACULTY OF MEDICINE
P. O. Box 166, Gulu

Peko ame ikweda man bi kelone ikomi

Peko moro ame bino yaa ikom ikweda man bino bedo ape, kekeni cawa ni ama ibino jalo me miyo agami ikom ikweda man

Gwoko imung:

Obino gwoko imung angat acelacel kede agam ame en bino miyo me bedo pi ikweda man keken

Bedo ni agonya.

Itye kede twero me kwero miyo tami ikom ikweda man ka pe imito bedo iye. Pe obedo dic

Cul.

Pe tye culoro keken ame yin obino culi kede me wek yin ibed iyi ikweda man, dang dok pe obino culi pi gamo apeny ame obino miyo bangi

Apeny ka tye

Ka itye kede apenyoro keken ame kwako ikweda man, itwero goyo cim bot ngata ame loo wii ikweda man Okwany Alex, I nama cim 0773252928 onyo itwero cwalo kwena email alexokwany@gmail.com.

Ka oturu twero ni

Miyo tam ikom ikweda man dic pe iye dong itye agonya me miyo tami onyo kwero oko.

Ka peko moro omaki onyo oturu twero ni ikare me timo ikweda man, itwero miyo ngec bot adit ame loo lok me pwonye kede timo ikweda i Gulu university, Dr. Gerald Obai i Nama cim., 0772305621; email: lekobai@yahoo.com/lekobai@gmail.com; onyo mi ngec bot Uganda National Council for Science and Technology, ame tye iwii plot 6 Kimera Road, Ntinda, Kampala inama cim 0414705500.

Yeo ni

An……,Oweko angeyo ngo ame bino timere, peko ame bino bedo iyi ikweda man, ber ikweda man kede twero na ame lubere kede ikweda man. Anyang aber dong amoko tama me bedo iyia akina jo ame bino miyo tam gi i kom ikweda man.

Nyingi agam apeny ……..cing ……nino dwe ……...

Nyingi acaden …….…… cing ……nino dwe…….

Nyingi ami apeny ……..…….. cing ……nino dwe…….

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P. O. Box 166, Gulu

Appendix C: Questionnaire

CHICKEN FARMERS QUESTIONNIRE

Greetings,

My name is **Alex Okwany**, a graduate student at Gulu University. I am undertaking a research study entitled "Effect of biosecurity practices on chicken health in Lira city, Northern Uganda". I invite you to take part in this study. The findings of this research will inform the government and other development agencies on strategies to improve chicken productivity in this region. Your responses and opinions are very important to us and they will be completely anonymous and confidential. All the data will be aggregated and hence, individual respondents will not be identifiable. The information from the survey will be used only for academic research. Your responses will be highly appreciated. Thank you.

Sincerely,

Alex Okwany.

SECTION A: DEMOGRAPHIC INFORMATION (Fill or Tick the appropriate response).

1. Participant code……
2. Cell…… Ward ……City division ……
3. Age in years……
4. Sex: Male ☐ Female ☐
5. Educational level: Informal ☐ Primary ☐ Secondary ☐ Tertiary ☐
6. Household size: a) 1-person ☐ b) 2-3 people ☐ c) 3-4 ☐ d) 4-5 ☐ e) >5 ☐
7. Estimated monthly household income ……
8. Marital status. Single ☐ Married ☐ Divorced ☐ Widowed ☐

SECTION B: GENERAL INFORMATION (Fill or Tick the appropriate response).

1. How long have you been in chicken farming? (years)……..
2. Average farm land size (acres) used for chicken farming ……
3. Breeds of chicken kept
   a) Exotic chicken ☐ b) Local chicken ☐ c) Improved chicken ☐
4. How many birds do you have on your farm now? ……

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5. How many birds have you kept on your farm in the last one year? .....
6. Which method of rearing chicken are you practicing:
   a) Free range/ Open system ☐ b) Semi intensive system ☐ c) Intensive/ Deep litter system ☐
7. Number of employees on the farm.....
8. Have you received training on biosecurity practices in chicken farming?
   Yes ☐ No ☐
9. If **yes**, what kind of biosecurity practices were you trained on?
   .....
   .....
   .....
   .....
10. Have your employees received training on biosecurity practices in chicken farming
    Yes ☐ No ☐

SECTION C: EXTENT OF USE OF BIOSECURITY PRACTICES

Please indicate how often the following practices are conducted on the farm (1= Never, 2= rarely, 3= Sometimes, 4= frequently, 5= Everyday)

	Biosecurity practices	**1**	**2**	**3**	**4**	**5**
	CLEANING & DISINFECTION					
1	Cleaning of the poultry house(s)					
2	Cleaning of feeding and drinking troughs, tools, and equipment daily					
3	Disinfecting the feeding troughs, equipment, and poultry house					
4	Washing of hands before and after entering the chicken house					
5	Use of dirty water (e.g., from washing clothes) to clean the poultry house					
6	Providing chicken with clean water for drinking					
7	Workers put on special clothing and footwear before entering the chicken house					
8	Adding disinfectant to the water in the footbath					
9	Fumigating the chicken house before new birds are brought in					
10	Cleaning the area around the chicken house(s)					

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11	Using practices to specifically keep rodents away					
	TRAFFIC CONTROL					
1	Restricting the number of people on the chicken farm at any given time					
2	Prohibiting vehicles from entering the farm					
3	Other animals are reared on the chicken farm					
4	Chickens on the farm mingle with other local and wild birds					
5	Birds access stored feeds					
6	The number of birds in the chicken house exceed its capacity					
7	Keeping a record of all farm visitors					
	ISOLATION					
1	Keeping birds of different ages in separate houses					
2	Restricting workers from visiting other chicken farms					
3	Exchanging/lending your farm equipment to other farms					
4	Separating sick birds from healthy birds					
5	Isolating new birds/birds brought from the market for at least 2 weeks before mixing them with other birds					
6	Examining flock for diseases					
7	Burning/burying of dead birds					
8	Separating eggs from the birds during transportation					
9	Recycling of feedbags and egg trays					

SECTION D: EFFECT OF BIOSECURITY PRACTICES ON CHICKEN HEALTH

1. What diseases often affect chickens on your farm?

   .....

   .....

2. How often do you register a diseased chicken?

   a) Every day ☐ b) 2-5 days a week ☐ c) Once a week ☐

   d) Once every two weeks ☐ e) Once a month ☐ f) <once a month ☐

3. How many chickens have fallen sick in the last one month? .....
4. How many chickens have fallen sick in the last one year? .....

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5. How do you as a farmer identify sick chicken?

.....

.....

.....

.....

6. How often do you register a loss (death) on your chicken farm?

a) Every day ☐ b) 2-5 days a week ☐ c) Once a week ☐

d) Once every two weeks ☐ e) Once a month ☐ f) <once a month ☐

6. How many losses (deaths) have you incurred in the last one month? .....
7. How many losses (deaths) have you incurred in the last one year?.....

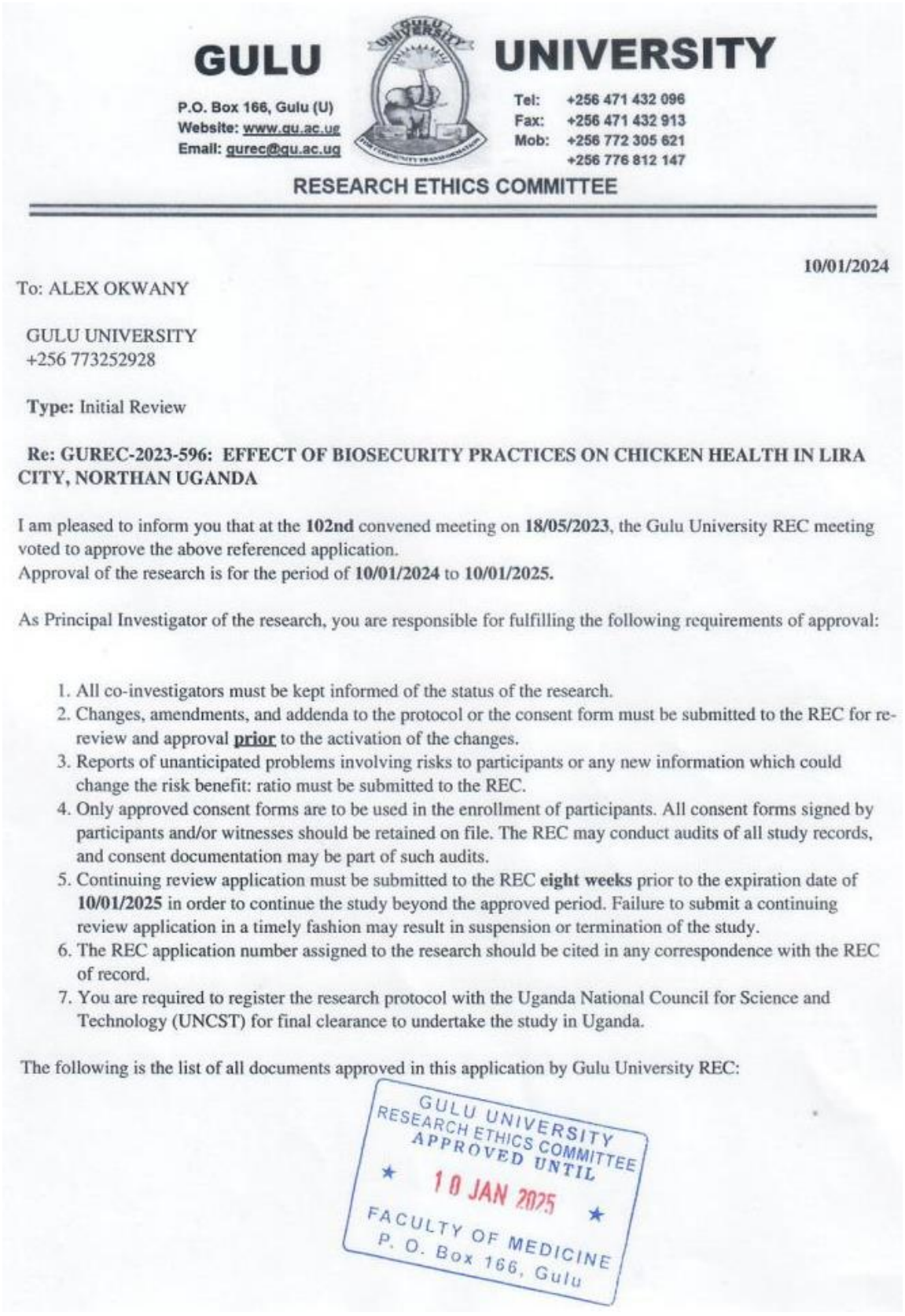
Thank you so much for your cooperation

Interviewer's name and signature.....

Date.....



Appendix D: GUREC Approval



GULU UNIVERSITY

P.O. Box 166, Gulu (U)
Website: www.gu.ac.ug
Email: gurec@gu.ac.ug

Tel: +256 471 432 096
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Mob: +256 772 305 621
+256 776 812 147

RESEARCH ETHICS COMMITTEE

10/01/2024

To: ALEX OKWANY

GULU UNIVERSITY
+256 773252928

Type: Initial Review

Re: GUREC-2023-596: EFFECT OF BIOSECURITY PRACTICES ON CHICKEN HEALTH IN LIRA CITY, NORTHAN UGANDA

I am pleased to inform you that at the **102nd** convened meeting on **18/05/2023**, the Gulu University REC meeting voted to approve the above referenced application.
Approval of the research is for the period of **10/01/2024** to **10/01/2025.**

As Principal Investigator of the research, you are responsible for fulfilling the following requirements of approval:

1. All co-investigators must be kept informed of the status of the research.
2. Changes, amendments, and addenda to the protocol or the consent form must be submitted to the REC for re-review and approval **prior** to the activation of the changes.
3. Reports of unanticipated problems involving risks to participants or any new information which could change the risk benefit: ratio must be submitted to the REC.
4. Only approved consent forms are to be used in the enrollment of participants. All consent forms signed by participants and/or witnesses should be retained on file. The REC may conduct audits of all study records, and consent documentation may be part of such audits.
5. Continuing review application must be submitted to the REC **eight weeks** prior to the expiration date of **10/01/2025** in order to continue the study beyond the approved period. Failure to submit a continuing review application in a timely fashion may result in suspension or termination of the study.
6. The REC application number assigned to the research should be cited in any correspondence with the REC of record.
7. You are required to register the research protocol with the Uganda National Council for Science and Technology (UNCST) for final clearance to undertake the study in Uganda.

The following is the list of all documents approved in this application by Gulu University REC:

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10 JAN 2025
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P. O. Box 166, Gulu

No.	Document Title	Language	Version Number	Version Date
1	Protocol	English	3	2023-12-23
2	Informed Consent forms	English	1	2023-11-12
3	COVID-19 risk management plan for the study	English	3	2023-11-12
4	Informed Consent forms	Lango	2	2023-08-18
5	Data collection tools	English	1	2023-05-04

Yours Sincerely

Julaina A. Obika

Julaina A. Obika (PhD)
For: Gulu University REC

GULU UNIVERSITY
RESEARCH ETHICS COMMITTEE
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10 JAN 2025
FACULTY OF MEDICINE
P. O. Box 166, Gulu

Appendix E: Introductory Letter

GULU UNIVERSITY

P.O. Box 166
Gulu, Uganda

Tel: 256- 471-42923
Fax: 256-471-42094

FACULTY OF AGRICULTURE AND ENVIRONMENT

Date: 15th January 2024

TO WHOM IT MAY CONCONCERN

RE: OKWANY ALEX (REG: NO: 20/U/2003/MSA/PS)

The above-named person is student pursuing a Master of Science in Animal production and Marketing Degree of Gulu University.

In partial fulfillment of the requirements for the award of the Master degree, she is carrying out research on the topic: "***ASSESSMENT OF EXTENT OF USE OF BIOSECURITY PRACTICES AND THEIR EFFECT ON CHICKEN HEALTH***".

I therefore take this opportunity to introduce Alex Okwany so that you accord him the necessary support.

Yours Sincerely,

0772886613/0750556651

Associate Professor Elly Ndyomugyenyi (PhD)
Head of Department
Animal Production and Range Management

Appendix F: Plaghrism Report

GULU UNIVERSITY

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PLAGIARISM CHECK

Declaration for Originality Form

This form must be completed and signed for all scholarly work produced.

Name: OKWANY ALEX (MR.)

Personal File No.(staff) Reg. (**student**). REG. NO. 20/U/2003/MSA/PS

Faculty/Institute: FACULTY OF SCIENCE, GULU UNIVERSITY

Department: BIOLOGY

Title and bibliographic description of the work

ASSESSMENT OF EXTENT OF USE OF BIOSECURITY PRACTICES AND THEIR EFFECT ON CHICKEN HEALTH

Declaration.

1. I understand what plagiarism is and I am aware of the University policy on this regard,
2. I declare that this … **Dissertation** … (Proposal, thesis, essay, assignment, paper, report etc.) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my work has been used, this has been properly acknowledged and referenced in accordance with Gulu University requirements,
3. I have not sought or used the services of any professional agency to produce this work,
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own,
5. I understand that any false claim of this work shall result in disciplinary action in accordance with University Policy on Plagiarism.

Signature _____ Date 27/11/2024

Originality Report

The article/thesis/document titled above have been subjected to plagiarism check and the level was found to be……**14%** (percent) this is classified as:

- ✓ Minor
- ☐ Moderate
- ☐ Serious

Yours sincerely,

Manana N Herbert
Ag. University Librarian

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