ID: 573

Appraisal of Awareness and Adoption Level of Biosecurity Practices for Disease Prevention and Control among Poultry Farmers in Jos South Local Government Area of Plateau State, Nigeria

Samuel Keghter Vihi[1*], Peter Musa Selzing[2], Birma Jesse[1], Binuyo Ganiyu[1], Enobong Donald Udoh[3], Chomini E.M[4] and Jacob Jeptha Mbah[5]

[1]Department of Agricultural Extension & Management, Federal College of Forestry, Jos Plateau State, Nigeria
[2]Montane Forest Research Station Jos, Plateau State, Nigeria
[3]High Forest Research Station, Awi, Calabar, Cross River State, Nigeria
[4]Department of Science Laboratory Technology, Federal College of Forestry, Jos
[5]Department of Statistics, Federal College of Forestry, Jos Plateau State, Nigeria

Özet

Abstract

This study evaluates the awareness and adoption levels of biosecurity practices for disease prevention and control among poultry farmers in Jos South Local Government Area of Plateau State, Nigeria. A total of 120 poultry farmers were randomly selected, and data were gathered through questionnaires and interviews. The results showed that 100% of the respondents were aware of key biosecurity practices such as hand washing, daily cleanliness, and vaccination. However, lower levels of awareness were found for practices such as disinfecting visitors and vehicles (76%) and keeping records of farm visitors (46%). The adoption of biosecurity practices was also uneven, with vaccination against infectious diseases being the most widely adopted practice, with a mean score of 3.8 on a 4-point scale, followed by the isolation of infected birds (3.7). Practices like quarantining new birds (2.7) and providing farm-specific clothing for workers and visitors (2.3) had lower adoption rates. The logit regression analysis revealed that education (P = 0.001), household size (P = 0.017), stock size (P = 0.012), and farm income (P = 0.012) were significant factors influencing the adoption of biosecurity practices. Age had a marginally significant negative effect (P = 0.057), suggesting that younger farmers are more likely to adopt these practices. The study concludes that while awareness of biosecurity practices is generally high, adoption is uneven, particularly for practices perceived as more complex or costly. It recommends targeted education and financial support to increase the adoption of underutilized biosecurity measures.

Key words: *Appraisal, awareness, adoption, biosecurity Practices, Diseases*

Introduction

The poultry industry is the most popular livestock enterprise adopted by small and medium scale farmers in both rural and urban areas of Nigeria (Afolayan Bawa, Sekoni, Abeke, and Daramola, 2014). Poultry production is the domestication of chicken for the purposes of egg and meat. It also generates income and creates employment opportunity for the populace. Poultry production is one of the easiest ways to increase the availability of protein in food because eggs contain essential nutrients such as amino acids, minerals and vitamins that can augment protein deficiency in the body. Poultry include chicken, turkey, guinea fowl, pigeon, ostriches, quail, peafowl, duck and goose. Production of meats and eggs occupies a prime position for improving animal protein consumption of both rural and urban households in Nigeria (Eze, Chah, Uddin & Anugwa, 2017; Alhaji & Suleiman, 2017). Poultry are efficient in producing high quality protein (meat and eggs) (Aiyedun *et al.*, 2018). The Nigerian poultry industry has the second largest chicken population in Africa after South Africa (SAHEL, 2015); producing 650 000 tons of egg sand 300000 tons of poultry meat (Central Bank of Nigeria (CBN), 2019 and FAOSTAT, 2017). According to CBN (2019), the poultry sub-sector is the most commercialized of all Nigeria's agricultural sub-sectors with a current net worth of N1.6 trillion and the sub-sector contributes about 25% of agricultural gross domestic product (GDP) to the Nigerian economy. Poultry production is an important source of animal protein, income generation, employment, industrial raw materials, manure and financial security. Poultry production outnumbers all other formsmof livestock production in Nigeria and it thrives well in any part of the country (FAO, 2018). According to Ozoedu, Eseonu, and Emanalom (2015), poultry production is the fastest means of correcting the shortage of animal protein intake, because it has the best efficiency of nutrient transformation into high quality animal protein. The Food and Agriculture Organization (FAO, 2021) reported that, Nigeria has low animal protein intake with an average of 6g per head per day while the world average is 34g per head per day. The significance of poultry farming to the economic, social and biological needs of people in any nation cannot be over emphasized (AGRIS-FAO, 2021).

In spite of these important contributions of the poultry industry, Nigerian poultry sector faces high production costs, bio-risks, safety and biosecurity concerns due to lack of sanitary controls and technical constraints in production, processing and marketing. Diseases remain one of the major threats to boosting poultry production in Nigeria (Adewole, 2012). The major diseases are the Newcastle disease, avian influenza, avian pox etc. with Newcastle disease being the most recognized by poultry farmers (Tasie *et at.*, 2020). Poultry farmers all over the world face endemic disease challenges that threaten poultry health, welfare and the profitability of the poultry enterprise. These diseases can have a substantial economic impact on individual enterprises and on the poultry industry as a whole (Wierup, 2012). Several attempts were made in the past to reduce the negative effects of infectious diseases from endangering the lives of chicken through medications and vaccination. However, these attempts proved abortive without the implementation and compliance to recommended standard biosafety practices (Lawal, El-Yuguda & Ibrahim, 2016). The incessant outbreak of diseases in the poultry industry have made the practice of biosecurity an essential practice to protect the poultry industry from bio-risks and threats from any disease producing agents and the prevention and control of these diseases depends on the adoption of biosecurity and best management practices. A successful animal production, including poultry, requires the adoption of good biosecurity practices (Van Limbergen *et al.,* 2017), which is the most effective and inexpensive disease control measure (Wijesinghe *et al.,* 2017).

Biosecurity has multiple meanings and is defined differently according to various disciplines. Biosecurity also referred to as biosafety is regarded as all the management practices aimed at excluding or reducing the potential for transmission and spread of diseases to animals, humans or an area initially free from the disease-causing agents (Eze *et.al*, 2017; Matilda, Ralf, Jurgen & Eva, 2020). It can also be defined as measures or practices taken to prevent or control the introduction and spread of infectious agents to a flock. Such infectious agents, whether they cause clinical or subclinical disease, significantly reduce the productivity, profitability and long-term financial viability of poultry production (Abah, Abdu, & Assam, 2017). Biosecurity in poultry refers to a set of practices and measures taken to limit, control, or prevent the introduction and dissemination of infectious diseases in the poultry premises and facilities (Eltholth *et al.,* 2016; Scott et al., 2018). Poultry farm biosecurity ranges from simple, low cost measures such as putting locks on gates to the more costly measures such as using high-pressure water sprayers to clean cars and constructing shower blocks to secure visitors and workers as they enter the farm. Some biosecurity activities are management changes, which may be low cost but require commitment from owners and farm workers to implement successfully. These include allocating a specific worker to a shed and not allowing staff to move from shed to shed. FAO (2016) and Kouam *et al.* (2018) classified biosecurity into three components. The classification based on the three components includes: Isolation, traffic control and sanitation. Isolation involves keeping birds protected from any source of infection like unauthorized access and carriers of disease, separating groups of animals to minimize the spread of infection across flock. Traffic control is the limitation of incoming human and material traffic within the farm and controlling the movement of equipment, vehicles, people, feeds, birds and eggs to prevent exposure to disease while sanitation is the regular cleaning, disinfection of poultry houses, equipment, vehicles, and people to eradicate disease causing agents (Abah, Abdu, & Assam, 2017; Oluwasusi, Akanni & Sodiq, 2018). A biosecurity program uses a combination of physical barriers such as fences, mesh wire, and directed actions to prevent the introduction of or minimize the spread of infectious disease causing agents including the use of footbaths, carwash deep, and disinfection of farm equipment (Aiyedun *et al.,* 2018). According to Maduka *et al.* (2016), Biosecurity consists of conceptual, structural, and operational frameworks. Conceptual category includes: the location of farms; structural: covering the building design and facilities to protect against entry of wild birds and predators; and operational: covering the routine disinfection, sanitation, and work procedures those farm employees and visitors follow. The biosafety operational cost is usually low and the benefit-cost ratio is high (Ifeduba, Achonwa, Ukwu, Ogbuewu, & Okoli, 2020), but inadequate implementation of biosafety practices may be due to insufficient sensitization, lack of understanding of its economic benefits and motivation (Matilda, Ralf, Jurgen, & Eva, 2020; Maduka, Igbokwe, & Atsanda, 2016). Strict biosafety measures, in addition to vaccinations, are strategies to prevent and control some infectious poultry diseases as vaccination alone is not enough to curb the menace under field conditions (Oluwasusi, Akanni & Sodiq, 2018). Good husbandry practices such as adequate feeding, housing and stocking to avoid overcrowding, good ventilation, proper disposal of wastes, cleaning and disinfection of poultry premises help to keep out infections and their spread (Mirza, Jaisan & Marya, 2020).

To avert human health risks (zoonosis) and economic losses, biosafety measures are inevitable in farms through isolation, limitations in number of visitors coming into the farm and/or sanitation practices. Poor or absence of biosafety practices in farms results in high levels of baseline mortality due to predators such as rodents, snakes, small carnivores or infectious diseases like Newcastle Disease-ND, salmonellosis, Gumboro disease or fowl typhoid. (Eze *et al.,* 2017). The structure of the commercial poultry industry in Nigeria is made up of sector two and three systems with little or no biosecurity and constant introduction of new birds from completely unknown sources thereby worsening the biosecurity problems (Oluwasusi, Akanni & Sodiq, 2018). The sector 1 systems are those with full compliance to biosafety management practices on regular basis (Oladipo, *et.al* 2020; Abah, Abdu, & Assam, 2017). Biosafety level in most commercial poultry enterprise is minimal or in some cases non-existing and this may lead to the spread of multiple infections within and between farms (Abah, *et.al* 2017). Performance of birds is influenced by the biosecurity measures of the farms (Wijesinghe *et al*., 2017). Biosecurity has direct relevance to food security and safety, nutrition security, the conservation of the environment (including bio - diversity), and sustainability of agriculture. Absence or neglect of biosecurity practices in poultry farms can give rise to unprecedented situations like high mortality rate, reduced profit and loss of investment. Biosecurity invariably posits quality assurance for poultry operators against high mortality losses and commercialization of safe poultry products that can guarantee good healthy chickens and poultry products raised and bought by consumers for healthy consumption. This could therefore assist the marketability, sustainability and optimal profitability of the poultry business over a long period of time. Biosecurity according to the Food and Agriculture Organization (FAO, 2016) has been identified as the only sustainable solution to reducing the negative effects of infectious pathogens on poultry. Therefore, based on the above background information, the broad objective of this study was to ascertain the biosecurity measures adopted by poultry farmers in Jos South Local Government Area of Plateau State, Nigeria. Specific objectives are to:

- describe the socioeconomic characteristics of poultry farmers in the study area;
- assess the awareness level of the respondents on biosecurity practices in the study area;
- identify the prevalent poultry diseases in the study area
- ascertain the biosecurity practices adopted by poultry farmers in the study area;
- determine factors influencing adoption of biosecurity practices.

Materials And Methods

The study was conducted in Jos South Local Government Area of Plateau State, Nigeria which is geographically located between latitude 90 300 to 100N and longitude 80 30'E of the Greenwhich meridian. It is located in the northwestern part of the state and is headquartered in Bukuru, 15 km from the state capital Jos. The local government consists of four districts: Du, Gyel, Kuru and Vwang. The Local government has a population of 650,835 (National Population Commission, NPC 2006) with an average land area of 1, 037km2. It borders the local governments of Barkin-Ladi to the south, Ryom to the southwest, Jos-Este to the east, and the local government of Bassa to the west. It is known for its cold and rocky nature due to its high altitude of over 1450 meters above sea level. The coldest period is between November and February, with an average daily temperature of 180C while warmer periods occur between March and April. The rains fall between May and October, with a peak in August. The mean annual rainfall varies between 137.75cm and 146.0cm. The Local Government is a semi-urban location but served with vast agricultural land, with mining ponds readily supplying water for irrigation. Common edible crops grown include rice, corn, Irish potatoes, yams, acha, sweet potato, cocoyam, tomatoes, peanuts, and assorted vegetables.

Sampling Procedure and sample size

The population for this study consists of poultry farmers in the four district of Jos South Local Government Area of Plateau State. They include: Gyel, Du, kuru, and Vwang districts. A list of all the registered poultry farmers in the Local Government Area was obtained from the local government office of Poultry Association of Nigeria. Thirty poultry farmers were randomly drawn from each of the districts of the LGA to give a sample size of one hundred and twenty (120) respondents for the study. The data were collected through the administration of questionnaires and oral interview.

Methods of Data Analysis

Descriptive statistics such as frequencies, percentages and mean were used to analyze the socio-economic characteristics of the respondents and to identify the prevalent poultry diseases in the study area. Four point Likert rating scale was used to examine the levels of awareness and adoption of biosecurity practices while logit regression was used to determine the factors influencing adoption of biosecurity practices among poultry farmers in the study area.

Likert scale

The level of awareness of biosecurity practices was measured using a four- point Likert scale. Here awareness score was calculated against a four-point scale: 'highly aware (HA), aware (A), fairly aware (FA) and not aware (NA)' weighted as 4, 3, 2 and 1, respectively. Based on the 4- point scale, a mid-point of 2.50 was established i.e. 4+3+2+1 ÷ 4 =2.5. Thus a decision rule was that, a mean value of 2.5 was used as cut-off point to determine the level of awareness of the respondents with respect to each of the biosecurity practices. Thus, biosecurity practices with mean score equal or above 2.5 were regarded as having high level of awareness while those with score below 2.5 indicated low awareness by the poultry farmers.

Similarly, level of adoption of biosecurity practices was measured using a four- point Likert scale. Here adoption score was calculated against a four-point scale: 'highly adopted (HA), adopted (A), fairly adopted (FA) and never adopted (NA)' weighted as 4, 3, 2 and 1, respectively. Based on the 4- point scale, a mid-point of 2.50 was established i.e. 4+3+2+1 ÷ 4 =2.5. Thus a decision rule was that, a mean value of 2.5 was used as cut-off point to determine the level of adoption of the respondents with respect to each of the biosecurity practices. Highly adopted and adopted were treated as positive response (High adoption) while fairly adopted and never adopted were treated as negative response (Low adoption). Thus, biosecurity practices with mean score equal or above 2.5 were regarded as those that received high level of adoption while those with score below 2.5 indicated low adoption by the poultry farmers i.e. adoption index score: high adoption: ≥ 2.50, low adoption: < 2.50

Logit Model Specification

The logit regression model is a unit or multivariate technique which allows for estimating the probability that an event occurs or not by predicting a binary dependent outcome from a set of independent variables. The logit model is based on cumulative logistic probability function and it is computationally tractable. According to Gujarati and Porter (2009), it is expressed as:

$$P_i = E(Y = 1 \| X_i) = B_1 + B_2X_2 \dots \dots + B_3X_3 \dots \dots \dots B_nX_n \quad (1)$$

For ease of estimation, equation (1) is further expressed as:

$$Pi = \frac{1}{1 + e^{-zi}} = \frac{e^{-z}}{1 + e^{-zi}} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \quad (2)$$

Where:
P_i = probability of an event occurring
$P_i = B_i + B_2 X_i$

The empirical model of the logistic regression for study assumed that the probability of the farmers' participation in community self-help projects is expressed as:

$$P_i = \frac{eb0 + b1\,X1 + b2\,X2 + b3\,X3 + b4\,X4 + b5\,X5 + b5\,X5 + b6\,X6 + b7\,X7 \dots + b9\,X9}{1 + eb0 + b1\,X1 + b2\,X2 + b3\,X3 + b4\,X4 + b5\,X5 + b5\,X5 + b6\,X6 + b7X7 \dots + b9\,X9} \quad (3)$$

P_i ranges between zero and one and it is non-linearly related to Z_i, . Z_i is the stimulus index which ranges from minus infinity to plus infinity and it is expressed as:

$$Z_i = In\left(\frac{\mathrm{Pi}}{1-\mathrm{Pi}}\right) \mathrm{b0} + \mathrm{b1\,X1} + \mathrm{b2\,X2} \dots \dots \dots \dots \dots \dots \dots \dots \dots + \mathrm{b9\,X9} + \mathrm{u} \quad (4)$$

To obtain the value of Z_i, the likelihood of observing the sample was formed by introducing a dichotomous response variable. The explicit logit model was expressed as:

$$Y = b_0 + b_1 X_1 + b_2 X_2 \dots \dots \dots \dots \dots \dots \dots \dots \dots + b_9 X_9 + u \dots \dots \dots \dots \dots \dots \dots \dots \quad (5)$$

Where:
Y = Adoption index of the respondents (i.e. mean index of 2.5 and above = High adoption, index below 2.5 = Low adoption)
X_1 = Age of farmers (Years)
X_2 = Gender (1 if male, 0 if female)
X_3 = Marital status (1 if married, 0 if otherwise)
X_4 = Educational level of farmers (Years of formal education)
X_5 = Household size (number of persons in the household)
X_6 = Stock size (number of birds)
X_7 = Poultry farming experience (years)
X_8 = Access to credit (1 if yes, 0 otherwise)
X_9 = Monthly income of farmers (Naira)
$b_{1-}b_9$ = Coefficients to be estimated
b_0 = Constant term
u = error term

Results And Discussions

Socio-Economic Characteristics of Poultry Farmers

Result in Table 1 below shows that 49% of the respondents were between the ages of 31-40 years, 25% were between the ages of 41-50, 18% were above 50 years while the remaining 8% were between the ages of 20-30. The mean age of the respondents was 41 years. This is an indication that poultry business in the area is dominated by persons in their economically active age who are more likely to adopt innovations faster than others in the older age brackets. Poultry farming is labour intensive and requires younger farmers who can cope with the tedious and rigorous biosecurity practices including disease management. This finding agrees with those of Tasie *et al*. (2020), Eze *et al* (2017) and Ibekwe *et al.* (2015).

Table 1 show that 59% of the poultry farmers are male while 41% were female. This implies that men dominate the poultry sector in the study area. The male dominance can be attributed to the fact that poultry farming is labour intensive and so discourage women from engaging in it. This finding is in line with the studies of Alalade *et al*. (2018) and Eze *et al*. (2017) who reported in their separate studies that poultry farming is dominated by the male folk.

The result also showed that 90% of the respondents were married while only 10% were single. Marital status has implication for the adoption of improved farm technologies. Married people tend to have more responsibilities and hence they take new technology with seriousness to increases their productivity. This result also indicates that the poultry business has helped to sustain the families. It therefore implies that the married couples could try to adopt biosecurity practices in order to improve the families' incomes and meat protein for family consumption.

The result in Table 1 further showed that 73% of the poultry farmers had attended tertiary institution and 20% had secondary school education while 7% had only primary education. This result indicates high literacy level among the respondents. In essence, it shows that the occupation is taken up by people who can read and write and more so read manuscript and labels on poultry feeds, poultry drugs and medication. This result collaborates that of Tasie *et al*. (2020), Eze *et al.* (2017) and Ibekwe *et al*. (2015) who in their separate studies also reported higher literacy level among poultry farmers. High educational attainment is very essential, since practice of biosecurity and disease management requires some level of literacy and technical knowledge. Education enhances the productivity, accountability and profitability of the farm business.

Table 1 also showed that respondents with household size of 1-5 persons had the highest (67.5%) percentage. This was followed by those with 6-10 persons (27.5 %) and those with 10 persons and above (5%). The mean household size of the respondents is 5 persons. The average household size of the respondents is equal to the national average of 5 persons in Nigeria (NBS, 2009). This number is quite reasonable for any significant biosecurity improvement and achievement by the respondents in the study.

The study also reveals that 38% of the farmers raise flock size of 1001 – 2000 birds, 24% raise 2001 – 3000, 16% had 3001 – 4000, 13% had 500 - 1000 birds while 9% of the farmers raised above 4000 birds in their farms. The average stock size of the farmers was 2234 birds.

The result also showed that most (51.7%) of the respondents use deep litter system of poultry management. In the deep litter system, poultry birds have direct contact with their faecal matter. This implies high risk of infection and disease, which will result in high medication costs, increasing the overall cost of production Eze *et al*. (2017). In the battery cage system, the poultry droppings fall on the floor beneath the cages so the poultry birds have no contact with their faecal matter. This helps to reduce health risks and expenditure on drugs (Ayadole, 2016).

On farming experience, the result showed that 52% of the respondents had the highest poultry farming experience of between 6-10 years, 31% had between 1-5 years, 17% had poultry farming experience above 10 years. The average poultry farming experience was 7 years. This result implies that the respondents had reasonable experience in poultry farming. Long farming experience is an advantage for increased poultry production since it may encourage rapid adoption of improved practices. Bakut (2013) asserted that farmers with long years of farming experience would be conversant with the constraints and this would increase their level of acceptance of biosecurity measures as means of overcoming their production constraints.

The annual income of poultry farmers in the study area reveals that 32% of the farmers earned between ₦2001,000 – 300,000 followed by 27% who earned between ₦301,000 - 400,000. 16% of the farmers earned above ₦ 400,000 while the remaining 7.5 earned between ₦50,000 – 100,000 as annual income. The mean annual income of the farmers was ₦279004. It can be seen from this result that the annual income of poultry farmers in the study area is fairly enough to enable them adopt most of the biosecurity measures. With this result, it is likely that the adoption of biosecurity practices will be favourable because income is very important in adoption process.

All (100%) of the respondents of the responded selected were members of the poultry association of Nigeria (PAN) as well as others associations. Membership of farmers' association is very important because it is an avenue by which people come together to achieve in group what they cannot achieve alone. For example, membership of association can serve as a means to access credit, labour and information on techniques and enterprises.

The result further shows that 76% of the respondents have not had any visit from the extension agents or to the extension agents in all their years of poultry farming. Only 24% of the respondents have had visit from the extension agents in the last two years indicating that the rate of extension visit is poor. This implies that most of the farmers were not adequately informed on current and emerging issues in poultry production such as biosafety practices.

The result also showed that 38% of the respondents had access to credit while 62% of the respondents did not access credit. Access to credit is a very important factor in agricultural enterprise. Credit is a very strong factor needed to acquire or develop an enterprise. Without credit most farmers cannot afford recommended biosecurity measures because of the capital intensive nature of some of these practices amidst low incomes. Most of these farmers are not considered credit worthy because they have no collateral. The farmers that have access to credit may be due their membership of cooperative groups.

Table 1. Distribution of Respondents According to socio-economic characteristics

Variable	Frequency	Percentage	Mean
Age			
20-30	10	8.0	
31-40	59	49.0	
41-50	30	25.0	
>50	21	18.0	41
Gender			
Male	71	59.0	
Female	49	41.0	
Marital status			
Married	108	90.0	
Single	12	10.0	
Educational level			
Primary	8	7.0	
Secondary	24	20.0	
Tertiary	88	73.0	
Non formal	-	-	
Household size			
1-5	81	67.5	
6-10	33	27.5	
>10	6	5.0	5
Poultry farming experience			
1-5	37	31.0	
6-10	62	52.0	
<10	21	17.0	7
Stock size (No. of birds)			
500 - 1000	16	13.0	
1001-2000	45	38.0	
2001-3000	29	24.0	
3001-4000	19	16.0	
>4000	11	9.0	2234
Management system			
Deep liter system	79	66.0	
Battery cage system	41	34.0	
Annual income from poultry business			
50,000.00-100,000	9	7.5	
101,000-200,000	21	17.5	
201,000-300,000	38	32.0	
301,000-400,000	33	27.0	
>400,000	19	16.0	279004
Membership of cooperative			
Yes	120	100	
No	0	0.0	
Extension contact of the respondents			
Yes	29	24.0	
No	91	76.0	
Access to credit			
Yes	46	38.0	
No	74	62.0	

Source: Field survey (2024)

Common Poultry Diseases in the Study Area

The data in Table 2 offers a detailed view of the distribution of common poultry diseases among farmers in the study area. A closer analysis of the results reveals the varying prevalence and the potential challenges poultry farmers face in managing these diseases. Below is a comprehensive discussion of the findings:

Newcastle Disease (ND) is reported by 73% of respondents, making it the most common and concerning disease in the study area. ND is a highly contagious viral disease that can cause high mortality rates in unvaccinated flocks. Its dominance in this table suggests significant challenges related to vaccination, biosecurity, and disease control measures among poultry farmers.

Infectious Bursal Disease, also known as Gumboro, affects more than half of the respondents (52%). This viral disease, which primarily impacts the immune systems of young chickens, is also quite widespread in the study area. The fact that it affects a significant portion of farmers highlights the need for consistent vaccination programs and effective management practices to protect flocks.

Avian Influenza, reported by 41% of respondents, is another major concern. This disease is highly contagious and can result in severe losses due to its impact on both bird health and public health. The presence of Avian Influenza requires strict biosecurity measures, surveillance, and rapid response mechanisms to prevent widespread outbreaks and to protect the livelihoods of poultry farmers in the area.

Coccidiosis, affecting 39% of respondents, is a parasitic disease that can thrive in environments with poor sanitation and overcrowded conditions. The relatively high frequency of this disease in the study area suggests that many farmers may struggle with maintaining optimal hygiene on their farms, which is essential for controlling the spread of Coccidiosis. The use of anti-coccidial drugs and improved farm management practices are crucial to mitigating the effects of this disease.

Fowl Cholera, a bacterial disease, affected 22.5% of the respondents. Although less prevalent than viral diseases such as ND and Gumboro, Fowl Cholera remains a significant issue, as it can cause sudden deaths and severe drops in production. The presence of this disease among a sizable number of respondents indicates that biosecurity measures and hygiene practices may need to be strengthened in certain areas.

Fowl Pox, affecting 19% of respondents, is a viral disease that typically causes skin lesions or respiratory problems. Although not as deadly as some of the other diseases on this list, Fowl Pox can still significantly reduce productivity, particularly in smallholder farms with limited resources for disease control. Vaccination is an effective way to prevent Fowl Pox, and improving awareness and access to vaccines could help reduce its incidence.

Marek's Disease, reported by 11% of respondents, is a viral disease that causes tumors and paralysis, leading to substantial losses in unvaccinated flocks. The relatively low prevalence may suggest that some farmers are using preventive vaccination effectively. However, for those affected, the disease can be devastating due to its chronic nature and impact on bird productivity. Promoting widespread vaccination against Marek's Disease is essential to reducing the disease's impact on poultry farms in the area.

Salmonellosis, a bacterial disease, was reported by 7.5% of respondents. While its prevalence is lower compared to other diseases, it can still be a concern due to its zoonotic potential and the impact it can have on both poultry health and food safety. The low frequency may reflect better management practices or awareness about preventing this disease. Ensuring proper hygiene, sanitation, and control of feed and water sources is important to prevent Salmonellosis from becoming more widespread.

Table 2. Distribution of Respondents based on Common Poultry Diseases in the Study Area

Disease	***Frequency**	**Percentage**
Newcasttle disease (ND)	88	73.0
Fowl pox	23	19.0
Infectious bursal/Gumboro	62	52.0
Fowl cholera	27	22.5
Coccidiosis	47	39.0
Avian influenza	49	41.0
Salmonellosis	9	7.5
Marek Diseases	13	11.0

Source: Field survey (2024); *Multiple responses

Poultry Farmers Awareness of Biosecurity Practices

Table 3 presents the distribution of respondents' awareness of basic biosecurity practices in poultry farming. The data reveals varying levels of awareness among respondents regarding essential biosecurity measures. Findings revealed that all respondents (120) demonstrated awareness of some critical biosecurity practices, indicating a strong foundation in fundamental biosecurity measures. They are: hand washing with soap before and after handling birds/products, daily cleanliness of litter, burying or burning of dead birds, vaccination against infectious diseases, limiting non-essential human traffic on the farm, providing foot-dip with disinfectant, avoiding rodents in/around of poultry house/feed bins, isolation of infected birds and examining flocks daily for disease symptoms. Practices with partial or moderate awareness include; disinfecting cars, bikes, trucks, visitors, and others before entering the farm (76.0% aware, 24.0% not aware), disinfecting outside equipment brought into the farm (84.0% aware, 16.0% not aware), fumigation of poultry house (73.0% aware, 27.0% not aware), quarantine of new birds (80.0% aware, 20.0% not aware). Practice with low awareness include; restraining farm workers from visiting other farms (47.0% aware, 53.0% not aware), Providing farm-specific clothes and footwear for employees and visitors (56% are aware, while 44% are unaware), Keeping a record of all farm visitors (46% are aware, with 54% unaware). Efforts should focus on increasing awareness and compliance with practices that have lower levels of awareness, possibly through targeted training programs. Awareness and knowledge of a technology is a prerequisite for its use as farmers with firsthand information from research and extension agents have higher awareness and use in all introduced technologies (Abdoulaye *et al.*, 2014).

Table 3. Distribution of Respondents based on Awareness of Basic Biosecurity Practices

Biosecurity Practices	**Level of Awareness**	
	Aware (%)	**Not aware (%)**
Hand washing with soap before and after handling birds/products	120 (100.0)	-
Daily cleanliness of litter	120 (100.0)	-
Burying or burning of dead birds	120 (100.0)	-
Disinfect cars, bikes, trucks visitors and others before entering the farm	91 (76.0)	29 (24.0)
Disinfect outside equipment brought into the farm	101 (84.0)	19 (16.0
Vaccination against infectious diseases	120 (100.0)	-
Fumigation of poultry house	88 (73.0)	32 (27.0)
Limit non – essential human traffic on the farm	120 (100.0)	-
Providing foot-dip with disinfectant	120 (100.0)	-
Avoid rodents in/around poultry house/feed bins	120 (100.0)	-
Quarantine of new birds	96 (80.0)	24 (20.0)
Isolation of infected birds	120 (100.0)	-
Restraining farm workers from visiting other farms	56 (47.0)	64 (53.0)
Examine flocks daily for disease symptoms	120 (100.0)	-
Farm's specific cloth and foot wears for employees and visitors	67 (56.0)	53 (44.0)
Keep a record of all farm visitors	55 (46.0)	65 (54.0)

Source: Field survey (2024)

Adoption of Biosecurity Practice by the Poultry Farmers

The table 4 presents the distribution of respondents based on the adoption of biosecurity practices using a Likert scale where HA (Highly Adopted) = 4, A (Adopted) = 3, FA (Fairly Adopted) = 2, and NA (Not Adopted) = 1. The table provides both the sum and mean scores for each biosecurity practice, reflecting the degree of adoption among respondents.

*Vaccination against infectious diseases (3.8)****:*** This practice is the most highly adopted biosecurity measure, indicating strong awareness of its importance in preventing widespread disease outbreaks, such as Newcastle Disease or Avian Influenza. With a mean score close to the maximum (3.8), nearly all respondents are consistent in vaccinating their flocks. This is critical for disease prevention, as vaccination significantly reduces mortality and maintains productivity. Continued availability of vaccines and farmer training on new diseases will help sustain this high adoption rate.

*Isolation of infected birds (3.7)****:*** Isolation is crucial to prevent the spread of disease among birds. With a high mean score of 3.7, this practice is well implemented. Immediate isolation of sick birds helps farmers control disease outbreaks early. Since biosecurity breaches can occur from cross-contamination, farmers likely recognize this practice's importance. Further education on early disease detection and isolation protocols can improve effectiveness.

*Hand washing with soap before and after handling birds/products (3.6)****:*** This practice is widely adopted with the majority of respondents scoring it highly. Hand washing is a fundamental biosecurity measure that reduces the spread of pathogens between birds and humans or birds to birds. The near-universal adoption (3.6) suggests that awareness campaigns have been effective. However, continuous reinforcement is necessary to ensure no complacency occurs, especially since any lapses in hygiene can have rapid consequences in densely populated poultry environments.

*Daily cleanliness of litter (3.3)****:*** Clean litter is essential to prevent the build-up of harmful pathogens. While the mean score of 3.3 indicates reasonable adoption, the variation suggests some farms may not clean litter as regularly. This is important because wet and dirty litter can harbor bacteria, viruses, and parasites that can affect poultry health. Increased education about the dangers of poor litter management could push this adoption rate higher.

Avoiding rodents in/around poultry house/feed bins (3.3): Rodent control is moderately adopted. Rodents can introduce diseases like salmonella into the poultry house, and their presence can contaminate feed and water sources. A score of 3.3 suggests farmers are reasonably aware, but more needs to be done to achieve universal rodent control. Rodent-proofing poultry houses and using traps or safe rodent poisons can be emphasized during training.

Disinfecting vehicles and visitors before entering the farm (3.0): Disinfecting vehicles and visitors is moderately adopted, with a mean score of 3.0. This measure is essential in preventing external contamination from entering the farm. Since farm equipment, vehicles, and visitors can carry pathogens, failing to disinfect them exposes farms to risk. While the mean score shows many farmers do implement this practice, a significant portion may not be rigorous enough. Educating farmers on how cross-farm contamination can introduce disease into biosecure farms could improve adoption.

Fumigation of poultry house (2.8): Fumigation is another moderately adopted practice, with a mean score of 2.8. This suggests that while farmers understand its role in disinfecting poultry houses, some may not see it as a regular requirement. Fumigation is an effective way to kill airborne pathogens and clean the environment post-flock removal. Increasing awareness of the timing and frequency of fumigation, along with demonstrations of its effectiveness, could boost this practice.

Providing foot-dip with disinfectant (2.8): Foot-dips are used to disinfect footwear and prevent the spread of pathogens. The adoption of this practice is moderate, with a mean score of 2.8, indicating room for improvement. Foot-dips are critical at farm entrances where staff and visitors enter. Training programs should highlight how easily pathogens can be carried on shoes and how simple it is to maintain a disinfectant foot bath.

Quarantine of new birds (2.7): Quarantining new birds before introducing them to the flock is essential to avoid introducing diseases. With a mean score of 2.7, many farms are not effectively quarantining new stock, potentially leading to disease outbreaks. Quarantine helps ensure new birds are free of diseases before being mixed with the flock. More focus should be placed on educating farmers about the dangers of mixing new and potentially infected birds with healthy ones.

Farm-specific clothing and footwear for employees and visitors (2.3): This practice is poorly adopted, with a mean score of 2.3. Farm-specific clothing helps prevent cross-contamination, yet many farms do not enforce this measure. This could be due to cost concerns or a lack of understanding of its importance. Providing affordable solutions for farm-specific clothing or subsidies could improve this practice.

Disinfecting outside equipment brought into the farm (Mean: 2.2): This practice has one of the lowest mean scores at 2.2, indicating low adoption. External equipment, when brought onto the farm, can be a major source of contamination, carrying pathogens that can infect the birds. Low adoption could stem from a lack of awareness or the perceived inconvenience of disinfecting every piece of equipment. Encouraging farmers to implement strict equipment disinfection protocols and showing the benefits in disease prevention could improve this score.

Restraining farm workers from visiting other farms (2.2): This practice has one of the lowest adoption levels. Workers who visit multiple farms are a significant risk for disease transmission. A mean score of 2.2 indicates that this practice is often overlooked, despite its importance in maintaining biosecurity. Farmers may underestimate the risk that human movement poses, and training programs should emphasize the necessity of restricting worker movement or enforcing hygiene protocols between visits.

Keeping a record of all farm visitors (2.2): With a low mean score of 2.2, record-keeping of visitors is another weak area. Visitor logs are critical for tracking potential sources of disease in the event of an outbreak. Farmers may not recognize the importance of maintaining these logs or might find it burdensome. Simplifying the process and explaining its role in biosecurity could lead to better adoption.

Practices with high mean scores, such as vaccination, hand washing, and isolation of infected birds, reflect a strong understanding among farmers of core biosecurity principles. These areas show that existing training and outreach have been effective, particularly in emphasizing the most direct ways to prevent disease spread. Low adoption practices like quarantining new birds, keeping visitor records, and providing farm-specific clothing indicate gaps in biosecurity. These practices, though often seen as less critical or time-consuming, are essential for preventing external sources of contamination. Targeted training programs should focus on these lower-scoring areas, using demonstrations and real-world examples to show the consequences of neglecting such measures.

Factors Influencing Poultry Farmers Adoption of Biosecurity Practices

The regression results in Table 5 provide insight into the factors influencing poultry farmers' adoption of biosecurity practices. Various socioeconomic and farm-related variables are analyzed to determine their significance in predicting adoption behavior. The Chi-Square value (14.30) is significant at the 5% level, indicating that the overall model is a good fit. This means the independent variables, taken together, significantly explain the variation in the adoption of biosecurity practices. The Hosmer-Lemeshow statistic

(4.88) and Pearson statistic (142.50) further assess model fit. Although these values are not significant, they suggest that the model fits the data reasonably well without major discrepancies. The significant determinants of biosecurity adoption are education, household size, stock size, farming experience, and farm income.

Age (X1): The coefficient of age is -0.0538, with a T-value of -1.90 and a P-value of 0.057, which is significant at the 10% level. This indicates that age has a negative but marginally significant effect on the adoption of biosecurity practices. As farmers' age increases, the likelihood of adopting these practices decreases slightly. Older farmers may be less inclined to adopt new practices compared to younger farmers, possibly due to traditional farming methods or resistance to change.

Education (X_4): Education has a positive and highly significant coefficient of 2.049 (P-value = 0.001). This suggests that higher levels of education have a strong positive impact on the adoption of biosecurity practices. Educated farmers are more likely to be aware of the benefits of biosecurity, understand the risks associated with disease transmission, and adopt preventive measures effectively. This variable is significant at the 1% level, indicating a robust relationship between education and biosecurity adoption.

Household Size (X_5): The coefficient for household size is -0.542 with a P-value of 0.017, making it significant at the 5% level. This negative relationship implies that as household size increases, the likelihood of adopting biosecurity practices decreases. Larger households may face more financial or labor constraints, potentially limiting the resources available for implementing proper biosecurity measures.

Stock Size (X_6): Stock size has a positive and significant coefficient of 0.0581 (P-value = 0.012). This indicates that larger flock sizes are associated with a higher likelihood of adopting biosecurity practices. Farmers with larger flocks may be more motivated to protect their investment, recognizing the importance of preventing disease outbreaks that could cause significant financial losses.

Table 3. Distribution of Respondents based on Adoption of Biosecurity Practices

Biosecurity practices	HA(4)	A(3)	FA(2)	NA(1)	Sum	Mean
Hand washing with soap before and after handling birds/products	308	129	-	-	437	3.6*
Daily cleanliness of litter	196	189	22	-	407	3.3*
Burying or burning of dead birds	128	222	28	-	378	3.1*
Disinfect vehicles/visitors before entering the farm	220	192	46	12	470	3.0*
Disinfect equipment brought into the farm from outside	44	69	132	20	265	2.2
Vaccination against infectious diseases	364	87	-	-	451	3.8*
Fumigation of poultry house	84	87	-	-	341	2.8*
Limit non – essential human traffic on the farm	188	189	20	-	397	3.3*
Providing foot-dip with disinfectant	92	198	20	-	343	2.8*
Avoid rodents in/around poultry house/feed bins	184	216	2	-	404	3.3*
Quarantine of new birds	84	132	110	-	326	2.7*
Isolation of infected birds	352	96	-	-	448	3.7*
Restraining workers from visiting other farms	44	63	142	17	226	2.2
Examine flocks daily for disease symptoms	396	63	-	-	459	3.4*
Specific wears for employees and visitors	40	78	164	-	282	2.3
Keep a record of all farm visitors	60	63	110	29	262	2.2

Table 5: Determinants of Poultry Farmers Adoption of Biosecurity Practices

Variable	**Coefficient**	**Std. Error**	**T-value**	**P-value**
Constant	-1.304	0.793	0.793	0.100
Age (X_1)	-.0538	.02831	-1.90*	0.057
Gender (X_2)	-0.149	0.181	-0.82	0.411
Marital status (X_3)	-0.302	0.432	-0.70	0.485
Education (X_4)	2.0490	.6040	3.39***	0.001
Household size (X_5)	-0.542	0.227	-2.39**	0.017
Stock size (X_6)	.0581	.0250	2.50**	0.012
Farming experience (X_7)	0.016	0.208	0.08	0.938
Access to credit (X_8)	0.237	0.828	0.29	0.775
Farm income (X_9)	1.2366	.4940	2.50**	0.012
Chi-Square	14.30**			
Hosmer-Lemeshow	4.88			
Pearson	142.50			

***, ** and *= Significant at 1%, 5% and 10%

Access to Credit (X_8): The coefficient for access to credit is 0.237 with a P-value of 0.775, indicating that access to credit is not a significant factor in determining the adoption of biosecurity practices. While credit can support farm investments, it does not appear to play a direct role in influencing biosecurity adoption in this sample.
Farm income (X_9): Farm income has a positive and significant coefficient of 1.2366 (P-value = 0.012). This suggests that higher farm income is associated with a greater likelihood of adopting biosecurity practices. Farmers with higher incomes are likely to have more resources to invest in biosecurity measures, such as vaccinations, improved housing, and sanitation, which help prevent disease outbreaks.

Conclusion

The study concludes that while the majority of poultry farmers in Jos South Local Government Area are aware of essential biosecurity practices, the adoption of these measures is still uneven. Key practices like vaccination and handwashing are widely adopted, while other measures such as quarantining new birds and keeping farm visitor records are less common. Factors such as education, household size, stock size, and farm income significantly influence the adoption of biosecurity practices. Older farmers, in particular, are less likely to adopt new biosecurity measures, possibly due to traditional farming methods or resistance to change. The findings highlight the critical role of education and economic factors in promoting the adoption of biosecurity practices, which are essential for preventing the spread of poultry diseases and ensuring sustainable poultry production.

Recommendations

The study's conclusions led to the following recommendations being made:
Enhance Education and Training Programs*:* Extension services should focus on educating poultry farmers, especially those with lower levels of formal education, on the importance of comprehensive biosecurity practices. Practical demonstrations and workshops on underutilized practices like quarantining new birds and maintaining visitor logs should be prioritized.
Target Younger Farmers*:* Programs designed to promote biosecurity practices should target younger farmers, who are more likely to adopt new technologies. Efforts should also be made to engage older farmers by demonstrating the economic benefits of adopting biosecurity measures.
Provide Access to Credit*:* Since financial constraints may hinder the adoption of biosecurity practices, the government and financial institutions should improve access to credit for small-scale poultry farmers. This will enable them to invest in critical biosecurity infrastructure and supplies.
Strengthen Farm Management Practices*:* Farmers should be encouraged to adopt better management practices, including regular farm inspections, disinfection of equipment, and the use of farm-specific clothing. Emphasizing the long-term cost savings from reduced disease outbreaks could motivate adoption.
Promote Cooperative Membership*:* Since cooperative groups can provide financial and technical support, farmers should be encouraged to join these associations. Cooperative membership can also facilitate the sharing of knowledge and resources related to biosecurity practices.

References

Adewole, S. O. (2012). Adewole, S.O. (2012). The efficacy of drugs in the treatment of coccidiosis in chicken in selected poultries. *Acad. Res. Int.*, 2:20-24.

Afolayan, M., Bawa, G. S., Sekoni, A. A., Abeke, F. O., & Daramola, S. T. (2014). Effect of inclusion level of African Locust Bean (Parkiabiglobosa) pulp in growth parameters of Egg type chicken. (0-20 weeks) *Nig. J. of An. Sc.*, 16(1), 51-60. view at Google scholar

AGRIS-Food and Agriculture Organization (FAO) (2021). Profitability, Input Elasticities and Economic Efficiencies of Poultry Production among Youth Farmers in Osun State, Nigeria. *International Journal of Poultry Sciences.* Vol 8(2): 994-998.

Aiyedun, J. O., Oludairo, O. O., Olorunsola, I. D., Daodu, O. B. and Furo, N. A. (2018). “Effectiveness of biosecurity measures in some selected farms in Kwara state, Nigeria,” *Journal of Research in Forestry, Wildlife & Environment*, vol. 10, no. 2, pp. 17–23, 2018.

Alhaji, N.B. & Suleiman, Y. (2017). Awareness and Mitigation Measures on Highly Pathogenic Avian Influenza in Pastoral Poultry Flocks of North-Central Nigeria: Any Challenging Gap. *Journal of Veterinary Medicine and Sciences*, 58(4): 157-161.

Balami AG, Ndahi JJ, Zaifada AU, Mustapha M, Jarafu DJ. (2014). A Retrospective Study of Poultry Diseases Diagnosed in Maiduguri, North-East, Nigeria. Poult Fish Wildl Sci 2: 113. doi:10.4172/2375-446X.1000113

Conan, A., Goutard, F. L., Sorn, S. and Vong, S. (2012).“Biosecurity measures for backyard poultry in developing countries: a systematic review,” *BMC Veterinary Research*, vol. 8, no. 1, p. 240, 2012.

Eltholth, M., Mohamed, R. Elgohary, F. and Elfadl, E (2016). Assessment of Biosecurity Practices in Broiler Chicken Farms in Gharbia Governorate, Egypt,” *Alexandria Journal of Veterinary Sciences*, vol. 49, no. 1, pp. 68–77, 2016.

El-Yuguda AD, Baba SS (2002) Prevalence of selected viral infections in various age groups of village chicken in Borno state, Nigeria. *Nigeria Journal Animal Production 29: 245-250.*

Eze, F. E., et al. (2017). Eze, C.O., Chah, J.M., Uddin, I.O., Anugwa, I.J., and Igbokwe, E.M. (2017). Biosecurity Measures Employed by Poultry Farmers in Enugu State, Nigeria. *Journal of Agricultural Extension*. Vol.21(3): 89- 104. https://doi.org/10.4314/jae.v21i3.9

Food and Agriculture Organization of the United Nations (FAO) (2016). The Biosecurity Approach: A review and Evaluation of Its Application by FAO, Internationally and in various 22nd December, 2016. http://doi.org/10.13140/RG.2.2.34154.52165

Food and Agriculture Organization of the United Nations (FAO) (2017). Why Bird Flu is Spreading in Nigeria. http://www.today.ng/news/nigeria/78409/whybird-flu-is-spreading-in-nigeria-fao.

Ifeduba, A.V., Achonwa, C.C., Ukwu, I.P., Ogbuewu, E.B., & Okoli, I.P. (2020). Commercial Intensive Poultry Production in Tropical Environments with Particular Reference to Nigerian Poultry Industry. *World Rural Observation. Marsland Press Multidisciplinary Academic Journal Publisher,* 12(3): 1-18.

Kouam, M. K.,. Jacouba, M., Nsangou, I. N. and. Teguia, A (2018). Assessment of Biosecurity Level in Small-Scale Broiler Farms in the Western Highlands of Cameroon (Central Africa),” *Tropical Animal Health and Production*, vol. 50, no. 7, pp. 1529–1538, 2018.

Lawal, J.R., El-Yuguda, A.D., & Ibrahim, U.I. (2016). Survey on Prevalence of Newcastle Disease in Village Poultry at Live Birds Markets in Gombe, Nigeria. *Journal of Animal Science Livestock Production,* Vol. 1(1):1-9.

Maduka, C.V., Igbokwe, I.O. & Atsanda, N.N. (2016). Appraisal of Chicken Production with Associated Biosecurity Practices in Commercial Poultry Farm Located in Jos, Nigeria. *Hindawi Scientifica Journal Research* Volume 6(2): 12-23.

Matilda, A.A., Ralf, K.J., Jurgen, M., & Eva, M., (2020). Understanding Attitude, Practices and Knowledge of Zoonotic Infectious Diseases Risks among Poultry Farmers in Ghana. *Journal of Veterinary Medicine and Science.* Vol 6(3): 4-9.

Mirza, M.M., Jaisan, I., & Marya, A. (2020). Investigation of Risk Factors and Biosecurity Measures Associated with Prevalence of Newcastle Virus in Broiler Farm. *Turkish Journal of Agriculture, Food Science and Technology,* 8(11): 2426-2432.

Oladipo, F.O., Bello, O.G., Daudu, A.K., Kayode, A.O., Kareem, O.W., Olorunfemi, O.D. & Iyilade, A.O. (2020). Adoption of Biosecurity Measures against Avian-Influenza Outbreaks among Poultry Farmers in Jigawa State, Nigeria. *Journal of Agricultural Extension Electronic Journals Service* (EJS), Vol. 24 (1): 85-94.

Oluwasusi, J.O., Akanni, Y.O., & Sodiq, A.R. (2018). Effectiveness and Benefits of Biosecurity Practices in Small-scale Broiler Farmers in Ekiti State, Nigeria. *Journal of Poultry Research* 15 (1): 6-12.

Ozoedu, E, Eseonu, B. O., & Emanalom, O. O. (2015). Performance of starting broiler chicks on Sandbox (Hura crepitans). Seed meal. Nig. J. of An. Prod. 42(1), 79-84.

SAHEL (2015). *An Assessment of the Nigerian Poultry Sector.*http://sahelcp.com/an-assessment of-the-Nigerian-poultry-sector/. SAHEL11: 1-3.

Sasaki, Y.,. Furutani, A. Furuichi T (2019). Development of a Biosecurity Assessment Tool and the Assessment of Biosecurity Levels by this Tool on Japanese Commercial Swine Farms,” *Preventive Veterinary Medicine*, vol. 175, Article ID 104848, 2019.

Scott, A. B., Singh, M., Groves P.(2018). Biosecurity Practices on Australian Commercial Layer and Meat Chicken Farms: Performance and Perceptions of Farmers,” *PLoS One*, vol. 13, no. 4, Article ID e0195582, 2018.

Singla, L. D. and Gupta, S. K. (2012). “Advances in diagnosis of coccidiosis in poultry,” in *Veterinary Diagnostics, Current Trends*, R. P Gupta, S. R Garg, V. Nehra, and D. Lather, Eds.,pp. 615–628, Satish Serial Publishing House, Delhi, India, 2012.

Tasie, C. M., Wilcox, G. I. and Kalio, A. E (2020)**.** Adoption Of Biosecurity For Disease Prevention and Control By Poultry Farmers In Imo State, Nigeria. *Journal of Agriculture and Food Sciences.* Volume 18, Number 2, October 2020, pp .Journal of the Faculty of Agriculture and Veterinary Medicine, Imo State University Owerri website: www ajol.info; Attribution: Non-commercial CC BY-NC)

Van Limbergen, T., Dewulf, J.,. Klinkenberg M et al., “Scoring biosecurity in European conventional broiler production,”*Poultry Science*, vol. 97, no. 1, pp. 74–83, 2017.

Wakawa AM, Mohammed ZK, Aliyu HB, Mohammed B (2012). A Retrospective Analysis of Marek’s Diseases Diagnosed at Poultry Clinic of Ahmadu Bello University, Zaria, Nigeria. *Journal of veterinary advances* 2: 424-429.

Wierup, M. (2012). Wierup, M. (2012). Principles and strategies for the prevention and control of infectious diseases in livestock and wildlife, *In* Ecology and Animal Health. L. Norrgren and J. Levengood, ed Bltic University Press. Uppsala, Sweden.

Wijesinghe, H. N., et al. (2017).

Wijesinghe, W. M. J. B., De Silva, P. G. J. C. and Gunaratne, S. P (2017). Evaluation of Biosecurity Status in Commercial Broiler Farms in Sri Lanka," *International Journal of Scientific and Research Publications,* vol. 7, no. 4, pp. 114–119, 2017.