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Poultry Farmers' Resilience to the Outbreaks of Disease in Oyo State, Nigeria

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Abstract

The study investigated the poultry farmers' resilience to disease outbreaks in Oyo State. A three-stage sampling technique was employed. Primary data were collected from 205 respondents with the aid of well- structured questionnaire. Descriptive statistics, Principal Component Analysis and probit regression were used to analyse data. The study showed that most farmers adopted some of the critical biosecurity measures (regular cleaning of the poultry pen, disinfecting the poultry pen before introducing new stock to the pen, infected birds isolated into a separate pen and provision of disposable footwear/footbath) to prevent disease outbreaks. Moreover, 81.2% and 25.0% of respondents with post-graduate certificates and no education had high and low resilience to disease outbreaks, respectively. The result revealed that 92.7% of the farmers with years of experience in the bracket 10-19 had high resilience to disease outbreaks. The result showed that years of experience and flock size positively influenced poultry farmers' resilience to disease outbreaks. The positive impact of poultry farming experience on resilience highlights the need for continuous training and knowledge-sharing programs. Agricultural extension services should be strengthened to provide both new and existing poultry farmers with timely information on disease prevention, farm management, and biosecurity practices.

Keywords: Resilience; Poultry industry; Mortality rate; Principal Component Analysis; Disease outbreaks

Introduction

The poultry industry is a vital sector in Nigeria, offering substantial economic and social benefits. Nigeria is the largest poultry producer in Africa and the second-largest egg producer on the continent [1]. According to the Poultry Association of Nigeria (PAN), the poultry industry contributes about 25% to the country's agricultural GDP, and it is estimated that over 20 million people are directly employed in the sector [2]. Despite the significant contributions of the poultry industry to the Nigerian economy, the sector has faced several challenges, including disease outbreaks, lack of access to finance and inputs, and poor infrastructure [3]. Disease outbreaks have severely impacted the resilience of poultry farmers, resulting in significant economic losses, reduced production, a decline in the supply of poultry products, a reduction in the number of poultry farmers (new entrants), increased prices for consumers and reduced income for farmers [4]. Kateba et al. (2022) found that small-scale poultry farmers are particularly vulnerable to disease outbreaks due to limited access to resources and services, poor management practices, and inadequate biosecurity measures. According to Grace et al. [5], smallholder farmers frequently give up on poultry due to health issues or disease outbreaks. The commonest diseases afflicting poultry in Nigeria are Newcastle disease, 31.2%, Gumboro 12%, Ectoparasitism 7.7%, Fowl pox 6.8%, Helminthiasis 6.6% and Coccidiosis 6.1%. Most outbreaks occurred in May and June with the highest incidence in 1989 [6]. According to Balami et al., Oluwayelu et al. [7], and Nwanta et al. [8], Newcastle disease and Immune Deficiency Disease (IBD) are the two most feared viral diseases affecting poultry in Nigeria. They cause illness, decreased egg production, immunosuppression, and frequent death when pathogenic strains of their various causative viruses are infected.

Poultry farmers generally adopt several coping strategies to ward off outbreaks of poultry diseases for the sustainability of their business [9]. These strategies include improving biosecurity, vaccination, and diversification of income sources. Brum et al. [10] posited that strengthening poultry farm biosecurity is often mentioned as the core strategy for improving the prevention and control of poultry diseases such as avian influenza, as well as for reducing dependence on antibiotics. Aside from vaccination which is a common strategy among poultry farmers, most farmers patronize reputable hatcheries for healthy day-old chicks. Generally, most farmers in Nigeria, adopt vaccination programs as a means of preventing disease outbreaks and reducing the impact of diseases on flocks. Vaccination against common poultry diseases such as Newcastle disease and Contagious Respiratory Disease is widespread among small-scale farmers in Nigeria. Moreover, the education of the farmer, experience in poultry, livelihood diversification and access to credit from social groups (e.g. cooperative society) foster resilience [11,12]. The outbreak of disease is the major reason new entrants abandoned poultry farming. In response to these challenges, the Nigerian government adopted several policies and initiatives aimed at boosting the poultry industry and enhancing its contribution to the economy. One such initiative is the Agricultural Transformation Agenda (ATA), which was launched in 2011. The poultry industry is one of the priority areas of the ATA, and several interventions have been implemented to support the sector, including the training of farmers on disease prevention and control measures [13]. In addition, the Nigerian government has also implemented policies aimed at boosting local production and reducing imports of poultry products. For example, in 2015, the government banned the importation of frozen poultry products to encourage local production and improve the competitiveness of local producers [14].

Moreover, on the state level, individual poultry farmers in Oyo State have employed several strategies to improve their resilience to poultry disease outbreaks [9]. According to the United States Agency for International Development report [15], resilience is the "ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks in such a way that reduces chronic vulnerability and facilitates inclusive growth". These strategies include improving biosecurity, vaccination, and diversification of income sources, being promoted by the Poultry Association of Nigeria, Oyo State chapter. Farmers have taken steps to control the movement of birds between farms and to purchase only healthy chicks from reputable hatcheries. Another strategy employed by farmers is vaccination. Many farmers in Oyo State, Nigeria, have adopted vaccination programs as a means of preventing disease outbreaks and reducing the impact of diseases on their flocks. Vaccination against common poultry diseases such as Newcastle disease and Contagious Respiratory Disease is widespread among small-scale farmers in Nigeria.

Despite the importance of the poultry industry and the challenges faced by farmers, there is limited research on the resilience of poultry farmers against disease outbreaks. The resilience of poultry farmers is essential to the sustainability of the poultry industry in Oyo State, Nigeria. Previous studies have focused on disease prevention in poultry Bagust [16]; Butcher and Miles [17]; Grace et al. [5]; Pirbright Institute [18], the resilience of farmers to climate change Mbabazi and Kikulwe [19], drought Matlou et al. [20], and child malnutrition [21]. The resilience of chicken farmers in Nigeria in the face of recurring disease outbreaks has not received much attention. This study will fill the gap by providing empirical evidence on the socioeconomic factors influencing resilience, the effectiveness of current adaptation strategies, and policy recommendations to enhance disease management. It is expected that this study will help poultry producers, agricultural extension agents, and policymakers understand the best ways to increase resilience. To lessen the impact of future outbreaks, it will also offer suggestions that support efficient biosecurity efforts. To achieve the objective of the study, the following research questions are raised:

i. What are the socio-economic characteristics of commercial poultry (egg and broilers) farmers and farm characteristics in the study area?

ii. What are the diseases that attack poultry birds, the extent of infection, the mortality rate and the coping strategies adopted?

iii. What is the resilience status of poultry farmers?

iv. What factors influence poultry farmers' resilience to disease outbreaks in the study area?

Theoretical framework and literature review

Three theories (resilience theory, sustainability livelihood framework and adaptive capacity theory) support the study. Resilience theory explains how systems (including farmers and their poultry enterprises) respond to shocks, adapt, and recover. The theory identifies three dimensions of resilience: absorptive capacity (ability to withstand shocks), adaptive capacity (ability to adjust strategies), and transformative capacity (ability to make long-term changes) [22,23]. The theory helps to analyse the various coping and adaptive strategies put in place by poultry farmers to recover from disease outbreaks for the sustainability of the poultry industry.

Chambers and Conway [24] stated that the Sustainable Livelihood Framework explains how farmers (most especially poultry farmers) use various resources (human, social, financial, physical, and natural capital) to sustain their livelihoods. Disease outbreaks disrupt farmers' flow of income and, by extension, access to necessary farm inputs. The ability/speed to recover varies from farmer to farmer. The framework helps to assess how poultry farmers in Oyo State mobilize their resources to enhance resilience and ensure sustainable farming practices [25]. According to Adger et al. [26], adaptive capacity theory focuses on the ability of individuals, communities, or systems to adjust to change, minimise damage, and seize opportunities. The theory highlights the role of knowledge (education and training), social networks (membership of associations), financial resources, and institutional support (extension services, Poultry Association of Nigeria, Nigerian Veterinary Medical Association, Central Bank of Nigeria) in helping poultry farmers respond to disease outbreaks. The theory of adaptive capability aids in assessing

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the efficacy of adaptation tactics, including enhanced biosecurity protocols (precautions put in place to prevent diseases), income diversification, and veterinary care accessibility.

The measurement of resilience is still debatable because it is a dynamic, multifaceted notion [27]. It is challenging to measure resilience, and various authors have put forth various methods. Since it is difficult to measure resilience, alternative measurement techniques or resilience indicators are frequently employed [28]. Access to basic services, assets, social safety nets, and adaptive capacity are the indicators used for developing the micro-level resilience index [29]. Principal Component Analysis (PCA) has been widely used in literature to generate a resilience index [30-33]. PCA is an ordination-based statistical data exploration method that creates a set of uncorrelated variables that capture the variability in the underlying data from several potentially correlated variables (that share a common property, such as points in time or space) [34]. According to Asadi et al. [35], PCA reduces noise since the maximum variation basis is chosen, and so the small variations in the background are ignored automatically.

Probit regression Lambert et al. [36]; Bennett et al. [37]; Panzeri et al. [38] is commonly used to measure determinants of binary dependent variables in resilience studies. Probit regression considers that anomalies are typically distributed, allowing for more efficient analysis when this assumption holds [39]. However, logistic regression serves the same purpose, but it has the limitation of assuming a linear relationship between the independent variables and the log odds of the dependent variable. If the relationship is not linear, the model may not accurately predict the probability of the event [40].

Analytical framework of probit regression

Following Hank et al. (2024), when the dependent variable is binary, the regression function is modelled using the cumulative standard normal distribution function Φ (.), which aligns with the assumption that:

$$E(Y|X) = P(Y=1|X) = \Phi(\beta_0 + \beta_1 X) \quad (1)$$

in eq. 1 plays the role of a quartile z,

From eq. 1, the change in z corresponding to a one-unit change in X equals the probit coefficient β_1. Because Φ is a nonlinear function of X, the relationship between z and the dependent variable Y is nonlinear, even though the effect of a change in X on z is linear. The coefficient of X has no straightforward interpretation because the dependent variable is a nonlinear function of the regressors.

Materials and Methods

Study area

The study was conducted in Oyo state, Southwest Nigeria. The state has an estimated population of over 5,591,589 [41]. It is located between latitude 7015’00”N, longitude 30 45’00” E and latitude 7034’00’’N, longitude 40 05’00’’E. It is bounded in the south by Ogun State, in the north by Kwara State, in the west by the Republic of Benin, and in the east by Osun State (Figure 1). The tropical climate of Oyo State features both dry and wet seasons, along with a comparatively high humidity level. The wet season begins in April and finishes in October, whilst the dry season runs from November to March. Nearly all year long, the average daily temperature falls between 25 °C and 35 °C. Oyo State’s vegetation pattern is guinea savannah (suitable for poultry production) in the north and rainforest in the south. In the north, tree-dotted grassland replaces the thick forest in the south [42]. The mean annual rainfall is 1480mm. Three Local Government Areas (LGAs) in Oyo state were considered for the study (Lagelu, Akinyele, and Egbeda LGAs). The main occupation of the residents in these LGAs is farming (crop and livestock: poultry). The crops commonly grown include arable crops like cassava, maize, cowpea, yam and vegetables. In addition to crop farming, these LGAs have a high concentration of poultry farms. Some of the towns/villages with a large number of poultry farms include: Olorunda, Lakuru, Idi-ape, Gbagi, Ojuurin, Elewuro, Egbeda, Olodo, Alakia, Apete, Ajia, Bole, Moniya, Ojoor, Orogun, Folarin, Sasa, and Odogbo.

Sampling procedure and sample size

A three-stage sampling technique was employed in selecting the sample for the study. The first stage involved a purposive selection of three Local Government Areas (LGAs) known for poultry production and contiguous in the study area. Lagelu, Egbeda and Akinyele LGAs are known to have a high concentration of poultry farms (egg and broiler production). The second stage involved the random selection of six towns/villages in each of the selected LGAs from the list obtained from the chairman of the local chapter of the Poultry Association of Nigeria. The third stage was a random selection of poultry farmers proportionate to size based on the list obtained from the local chapters of the Poultry Association of Nigeria. The number of respondents (egg and broiler producers) from each town/village was obtained by extracting 20 % of poultry farmers from each town/village (Table 1).

The sample sizes for the egg producers (136) and broiler producers (94) were arrived at using the International Fund for Agricultural Development (IFAD) procedure using eq. 2. The final sample size (230) used included allowances for the design defect and contingency. The allowance for design defect is expected to correct for the difference in design while the allowance for contingency accounts for contingencies such as non-response or recording error.

$$n = \frac{Z^2 P(1-P)}{M^2} \quad (2)$$

Where:

n represents the sample size;

Z represents the confidence level at 95% (1.96);

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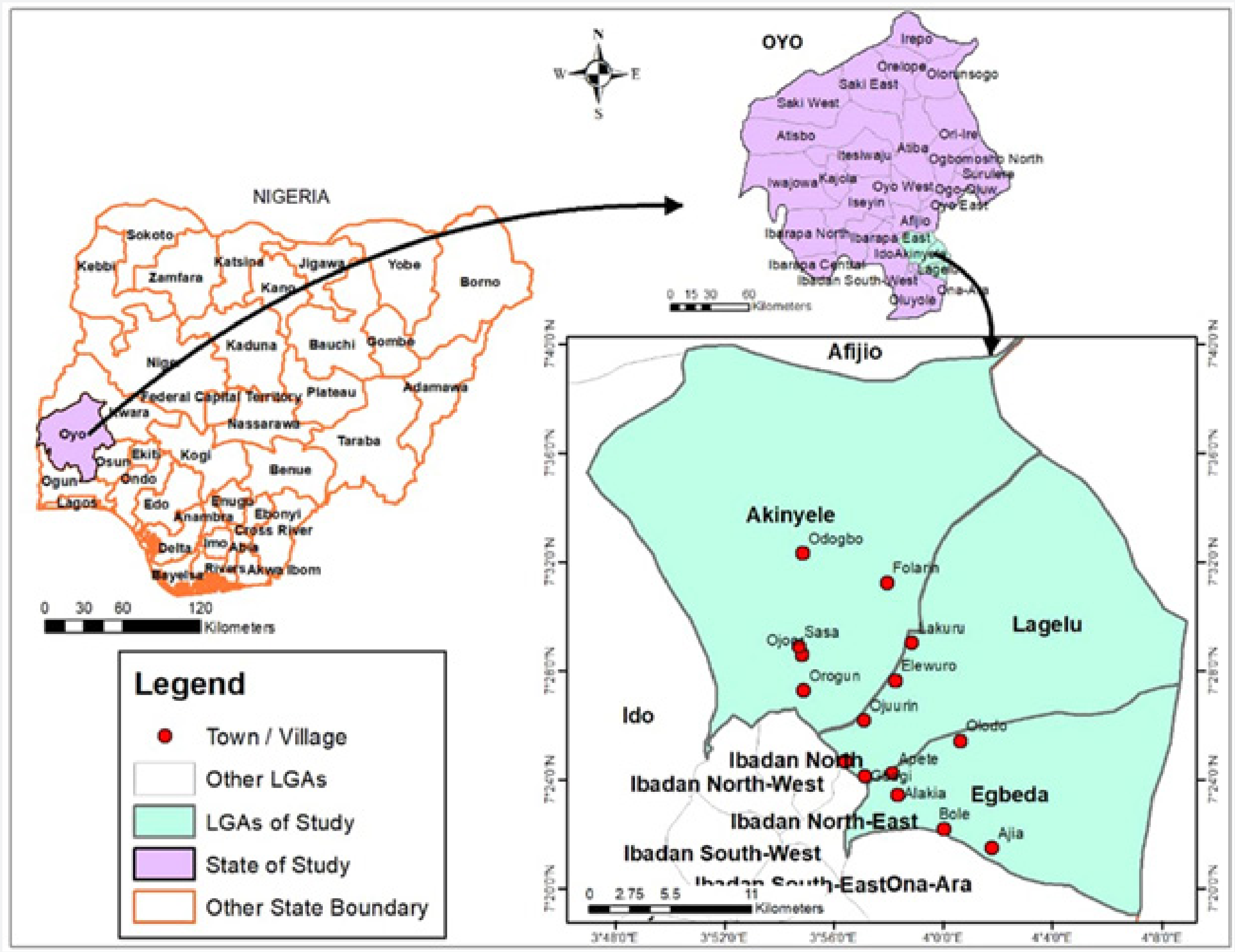
P represents the estimated percentage of egg producers (96%), and the estimated

Percentage of broiler producers (90%) in the study area; and

M represents the margin of error (5% or 0.05).

Moreover, a total of 230 copies of the questionnaire were administered to egg and broiler producers. Two hundred and five (205) copies of the completed questionnaire were successfully collected. Data were collected on the socio-economic characteristics of poultry farmers (egg and broiler producers). Data were also collected on management practices adopted to curb disease outbreaks, bio-security measures adopted on the farm, and distances from the poultry farm to the feed sellers and veterinary stores.



Source: Author's Map (2023).

Figure 1: Map of the study area (Akinyele, Lagelu and Egbeda LGAs).

Analytical techniques

Descriptive statistics (mean, standard deviation, skewness and frequency distribution), Principal Component Analysis and probit regression were utilized to achieve the objective of the study.

Principal Components Analysis (PCA)

The PCA is a dimension-reduction tool used to compress a large set of variables to a small set that still contains most of the information in the large set [43]. It was used to generate the resilience index of each poultry farmer using responses to specific questions. The PCA is specified as:

$$PC_{nm} = \rho_{n1}X_1 + \rho_{n2}X_2 + \ldots + \rho_{nm}X_m \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where:

ρ_{nm} represents the weight for variable X in the n^{th} and m^{th}

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(n =1, 2,...,n and m=1,2,...,m) principal component. Estimated principal components are sorted in descending order; consequently, the first principal component explains the greatest amount of variation in a data set, assuming that the total of the squared weights equals one. That is:

$$\rho_{i\,1}^2 + \rho_{i\,2}^2 + \rho_{i\,3}^2 + \ldots + \rho_{i\,j}^2 = 1 \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Table 1: Distribution of respondents based on sampling technique.

State	LGA	Town/Village	Population of poultry farmers	Number of respondents of egg producers	Number of respondents of broiler producers
Oyo	Lagelu	Olorunda	190	22	16
		Lakuru	115	14	9
		Idi-ape	95	11	8
		Gbagi	60	7	5
		Ojuurin	40	5	3
		Elewuro	30	4	2
	Egbeda	Egbeda	70	8	6
		Olodo	60	7	5
		Alakia	45	5	4
		Apete	65	8	5
		Ajia	30	4	2
		Bole	40	5	3
	Akinyele	Moniya	30	4	2
		Ojoor	45	5	4
		Orogun	75	9	6
		Folarin	55	6	5
		Sasa	35	4	3
		Odogbo	70	8	6
Total planned respondents			1150	136	94

Probit regression

Probit regression is a statistical technique used to model the relationship between a binary dependent variable (that takes on two possible outcomes, usually labelled as 0 and 1) and a set of independent variables. The probit regression was used to determine the factors influencing poultry farmers' resilience to disease outbreaks in the study area. The model is given as:

$$Y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9 + \mu_1 \ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where:

Y represents resilience status (respondent with high resilience = 1, respondent with low resilience = 0)

a_0 represents intercept

a_1 to a_9 represents regression coefficients

x_1 represents the age (years) of the respondents

x_2 represents sex of respondents (male = 1, female = 0)

x_3 represents marital status of respondents (married = 1, others = 0)

x_4 represents years of education of respondents

x_5 represents the years of poultry farming experience of respondents

x_6 represents the flock size of respondents

x_7 represents membership of association of respondents (Yes = 1, No = 0)

x_8 represents respondents' engagement in other economic activities (Yes = 1, No = 0)

x_9 represents mortality rate (%)

μ_1 represents the error term

Results and Discussion

Socio-economic characteristics of respondents

The study revealed that the majority (43%) of the poultry farmers were within the age bracket of 22-37 years (Table 2). The average age was 40.1 years. This finding agrees with the findings of Eze et al. (2017) and Ibekwe et al. (2015), who had similar results. Moreover, most of the poultry farmers were male (60%).

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The gender gap in favour of men was attributed to men having better access to production resources to enhance their livelihood options [44]. Moreover, majority (78.5 %) of the poultry farmers were married. Also, more than 47% (47.3%) of the respondents had HND/BSc certificates. According to Machuka [45], farmers who are educated are better able to adapt to changing conditions and overcome challenges, such as natural disasters, climate change, and market volatility.

Table 2: Socioeconomic characteristics of respondents.

Socio-economic characteristics of respondents	Frequency	Percentage (%)
Age (Year) Distribution		
22 - 29	44	21.5
30 - 37	44	21.5
38 - 45	51	24.9
46 - 53	43	20.8
54 - 61	20	9.8
62 - 69	3	1.5
Total	205	100
Mean	40.1	
Standard Deviation	10.1	
Skewness	0.1	
Sex		
Male	123	60
Female	82	40
Total	205	100
Marital status		
Single	39	19
Married	161	78.5
Divorced	2	0.9
Widowed	3	1.6
Total	205	100
Level of education		
No education	4	1.9
Secondary education	25	12.2
OND/NCE	46	22.4
HND/BSc	97	47.3
Post-graduate	32	15.6
Adult education	1	0.5
Total	205	100
Experience (Years) in egg production		
1 - 9	151	73.7
10 - 19	41	20
20 -29	12	5.8
30 - 39	1	0.5
Total	205	100
Mean	6.9	
Skewness	1.8	
Standard deviation	5.7	

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Flock size		
At most 500	116	56.6
501 - 5000	70	34.1
5001 and above	19	9.3
Total	205	100
Mean	1866.2	
Standard deviation	3606.6	
Skewness	3.3	
Distance to veterinary store (km)		
At most 1	103	50.2
1.1 - 2	61	29.8
2.1 - 3	18	8.8
3.1 and above	23	11.2
Total	205	100
Mean	1.56	
Standard deviation	1.65	
Skewness	0.28	
Distance to feed sellers (km)		
At most 1	131	63.9
1.1 - 2	47	22.9
2.1 - 3	10	4.9
3.1 and above	17	8.3
Total	205	100
Mean	1.33	
Standard deviation	1.71	
Skewness	4.30	

Source: Author's computation (2023)

Furthermore, the study posited that 73.7% of the farmers had been in the poultry business for at least nine years. This may be attributed to the perseverance of an average poultry farmer which enables them to stay in business despite various challenges. Also, as farmers spend more years in the poultry business, the more practical experience they acquire to manage and cope with certain problems associated with the emergence of diseases on poultry farms. This affirms the finding of Ezeh [46] who stated that the farming experience of farmers is directly proportional to knowledge gained to tackle farm production challenges. The average flock size was 1866 birds (Table 2). However, the majority of the poultry farmers had flock sizes below the average flock size in the study area (positive skewness). This is an indication that most poultry farmers in the study area were small-scale farmers. The average distance to the veterinary clinic was 1.56km. From the study, one may infer that poultry farmers located close to veterinary clinics would seek timely veterinary services and carry out disease prevention measures than farms located far away. Ogunsina and Omonona [47] affirmed that accessibility to veterinary services is a crucial factor in determining the resilience of poultry farmers against diseases.

Diseases incidence in poultry farms and extent of attack in the study area

Table 3 shows that the common diseases there are seven (7) common poultry diseases that attacked birds in the study area in the last production season. These diseases were gumboro, Newcastle, coccidiosis, fowl cholera, contagious respiratory disease, coryza, and gastro-intestinal worms. Among the diseases, coccidiosis (29.7%) was the most reported disease among the farmers. The type and extent of infection in poultry birds have a significant influence on the resilience of poultry farmers to disease attacks. This agrees with Adesokan et al. [48] who reported that high infectious diseases such as avian influenza and Newcastle disease resulted in more severe economic losses for farmers, which negatively affected their resilience over time. A study by Munir and Siddique [49] found that the mortality rate of poultry diseases is critical for the resilience of farmers as it affects their ability to maintain production levels and meet market demands.

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Table 3: Distribution of poultry diseases and the extent of infection.

Poultry diseases	Low incidence		Medium incidence		High incidence		Overall incidence	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Gumboro	27	7.9	14	21.9	1	7.1	42	10
Newcastle	62	18.2	16	25	2	14.3	80	19.1
Coccidiosis	105	30.9	15	23.4	4	28.6	124	29.7
Fowl cholera	24	7.1	5	7.8	0	0	29	6.9
Contagious respiratory disease	83	24.2	8	12.5	7	50	98	23.4
Coryza	13	3.9	4	6.3	0	0	17	4.1
Gastro-intestinal worms	26	7.8	2	3.1	0	0	28	6.7
Total	340	100	64	100	14	100	418	100

Source: Authors computation (2023).T3

Galvmed [50] affirmed that the out outbreaks of poultry diseases like Newcastle Disease (ND) severely affect productivity, flock mortality, and consequently, farmer livelihoods. The majority of the poultry farmers in the study area had mortality in the range of 1-5% (Table 4). However, the disease with the highest mortality rate recorded by poultry farmers in the study area was coccidiosis (38.5%). This was followed by Chronic Respiratory Disease (28.8%) and Newcastle disease (21.9%), respectively. According to Muñoz-Gómez et al. [51], coccidiosis is one of the leading morbidity causes in chickens, causing a reduction in body weight and egg production. Mohammed and Sunday [52] found that coccidiosis was more prevalent during the wet season in Nigeria. They identified suitable sanitary measures, avoiding water spillage, overcrowding, the use of prophylactic anticoccidials "shuttle programme" and vaccination to prevent disease outbreaks in the poultry industry. Galvmed opined that vaccination as a cost-effective means of controlling Newcastle Disease.

Table 4: Distribution of poultry farms mortality by major diseases.

Mortality (%)	Percentage of Poultry farms						
	Newcastle	Coccidiosis	Gumboro	Fowl Cholera	CRD	Int. Worm	Coryza
1 - 5	21.9	38.5	5.8	2.3	28.8	0.9	3.3
6 - 10	3.8	4.8	0.8	0.4	4.9	0	0.4
11 - 15	0.9	0	0.9	0	0	0	0
16 - 20	0.4	1.3	0	0	0.9	0	0

Table 5 shows the various measures adopted by respondents to control diseases. These were Biosecurity (BS), Vaccination (VN) and Good Husbandry and Hygiene (GH&H). According to the table, most respondents adopted some of the critical biosecurity measures. However, only 21.95% of the respondents located the brooding pen adjacent to the laying pen. According to House Instruction [53], the health and welfare of both groups may be affected if brooding pens are placed close to laying pens in poultry since this can cause disease transfer, particularly from older to younger birds, and disturb the normal flow of fresh air. Specifically, 46.3% and 56.6% of the respondents made provision for footbath and disinfection of vehicles that enter the farm, respectively. This may be attributed to the small-scale operation of most of the poultry farmers which makes the cost of putting the infrastructure and maintenance in place unaffordable. The table shows that 98.1% of the respondents used vaccination as a preventive measure. Vaccination is a common measure of disease control among poultry.

Marangon and Busani [54] affirmed that vaccinations against infectious poultry diseases are used extensively. By preventing or reducing the emergence of clinical disease at the farm level, they are used in chicken production to boost output. More than half of the poultry farmers had regular visits/contacts by veterinarians, while 45.4% had records of visitors. One crucial biosecurity procedure is to keep track of who has entered and left your farm, especially those who have been in production areas. The origin and possible spread of a pest or disease that can be carried on visitors' clothing or shoes may be ascertained using this information [55]. Moreover, Lichtensteiger [56] posited that in order to ensure flock health, avoid infections, and maximize output through their proficiency in biosecurity, disease management, and diagnostics, affiliate veterinarians are essential to the poultry sector.

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Variable components associated with the resilience status of respondents

Table 6 shows the flock size and the system of poultry management adopted which constitute the asset pillar both had positive resilient index of 0.71. This indicates that poultry farmers who have flock size and adopt management systems are resilient. Among the variables that constitute the adaptive capacity pillars, farming experience, farm insurance, restriction of non-essential traffic on the farm, allowing only clean, disinfected vehicles, record keeping of all farm visitors, one entrance/exit to the farm, and provision of disposable footwear had positive resilient indices of 0.37, 0.33, 0.13, 0.44, 0.47, 0.15, and 0.38 respectively which indicate that they are resilient to disease outbreaks. Membership of association and expert consultation which constitute the social safety nets pillars had resilient indices of 0.71 (with resilience) and -0.71 (without resilience) respectively. The poultry diseases which are categorized under the sensitivity pillars all had positive resilient index which indicates poultry farmers' resilience to the disease outbreak.

Table 5: Distribution of control measures adopted by respondents.

Disease control measures	Yes		No	
	Frequency	Percentage	Frequency	Percentage
Regular cleaning of the poultry pen (BS)	203	99.02	2	0.98
Disinfect the poultry pen before introducing new stock to the pen (BS)	194	94.63	11	5.37
Vaccination as at when due (VN)	201	98.05	4	1.95
Infected birds are isolated into a separate pen (BS)	195	95.12	10	4.88
Brooding pens are adjacent to the laying pens (BS)	45	21.95	160	78.05
Veterinarian/associate giving instructions or visiting the farm at intervals (GH&H)	140	68.29	65	31.71
Limiting non-essential traffic on the farm (BS)	163	79.51	42	20.49
Allow only clean, disinfected vehicles on the farm (BS)	116	56.59	89	43.41
Keeping a record of all farm visitors (GH&H)	93	45.37	112	54.63
Farm has one entrance/exit (BS)	107	52.45	97	47.55
Provision of disposable footwear/foot bath (BS)	95	46.34	110	53.66

Table 6: Principal Component Analysis (PCA) result of resilience indicators.

Variables	Component loadings
Assets	
Flock size	0.71
System of poultry management adopted	0.71
The proportion of variation explained	0.54
The eigenvalue of the first component	1.08
Kaiser-Meyer-Olkin measure of sampling adequacy (KMO)	0.5
Adaptive Capacity	
Farming experience	0.37
Education	-0.07
Farm Insurance	0.33
Engagement in other economic activities	-0.25
Sanitation of poultry pens	-0.11
Disinfection of poultry pens	-0.09
Vaccination of birds	-0.09
Isolation of infected birds	-0.05
Restriction of non-essential traffic on the farm	0.13
Allowing only clean, disinfected vehicles	0.44

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Record keeping of all farm visitors	0.47
One entrance/exit to the farm	0.15
Provision of disposable footwear	0.38
Keeping other animals and strangers off the poultry pen	-0.26
The proportion of variation explained	0.15
The eigenvalue of the first component	2.04
Kaiser-Meyer-Olkin measure of sampling adequacy (KMO)	0.53
Social Safety Net	
Membership of association	-0.71
Expert consultation	0.71
The proportion of variation explained	0.58
The eigenvalue of the first component	1.16
Kaiser-Meyer-Olkin measure of sampling adequacy (KMO)	0.5
Sensitivity	
Newcastle disease	0.43
Gumboro disease	0
Coccidiosis disease	0.35
Fowl cholera disease	0.34
Contagious respiratory disease	0.44
Coryza	0.59
Gastro-Intestinal worms	0.18
The proportion of variation explained	0.25
The eigenvalue of the first component	1.72
Kaiser-Meyer-Olkin measure of sampling adequacy (KMO)	0.57

Source: Authors computation (2023)

Resilience status of poultry farmers by socio-economic characteristics

Table 7 shows that 81.2% of farmers with post-graduate education were resilient to disease outbreaks. However, 25% of farmers who had no education had low resilience to disease outbreaks. This implies that the more educated poultry farmers are, the more resilient, and less vulnerable they would be to shocks of disease outbreaks. Farmers with no formal education may not be able to search for and apply the knowledge required to prevent and control the outbreak of diseases in their poultry farms. They may not withstand the various shocks that may affect their poultry business. This is in line with the findings of Brenda [57] who stated that the more educated poultry farmers are, the less vulnerable they would become to shock. Also, they would have a greater capacity to adapt than farmers with no level of education because they can obtain information about disease outbreaks.

The study shows that 92.7% of the farmers with years of experience in the bracket 10-19 had high resilience to disease outbreaks (Table 8). Expectedly, with 1-9 years of experience had low resilience to disease outbreaks. The low resilience among poultry farmers within this bracket may be attributed to their inexperience as new entrants to the rudiments of poultry farming. This agrees with the findings of Olayemi et al. (2019), they reported that farmers with more years of experience had better knowledge and skills in disease prevention, diagnosis, and management, which made them more resilient against poultry diseases. According to Inwood and Sharp (2012), strong farms continued to operate in a secure financial position, had buffers, or made the necessary investments to keep up present production methods, which allowed them to be maintained and optimized. These farmers were strong-willed, complied with traditional norms and beliefs, acquired agricultural knowledge, and frequently gained agricultural-related skills over the years.

Resilience status by flock size

Table 9 indicates that the majority (81.1 %) of the poultry farmers with a flock size of less than 500 had low resilience to disease outbreaks. However, 81.4 % of farmers with a flock size of 500-5000 had high resilience to disease outbreaks. This implies that as the flock size increases the level of resilience of farmers also increases. This may be attributed to the fact that most of the

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farmers who raised at most 500 birds may just be engaging in it as a secondary occupation and may not devote much time and attention to taking care of the birds while farmers with flock sizes of over 500 birds may be engaging in it as their main occupation and as such may prepare themselves against some eventualities in terms of capital, knowing the right people to meet in terms of belonging to an association and getting well educated on some basic things they need to know in poultry production. According to Biovatec [58], a poultry farm's ability to withstand disease outbreaks is greatly influenced by flock size and biosecurity procedures; smaller flocks may be more susceptible because of the speed at which diseases spread and the challenge of putting in place efficient control measures.

Table 7: Resilience status by socio-economic characteristics.

Level of education	Low resilience		High resilience	
	Frequency	Percent (%)	Frequency	Percent (%)
No education	3	75	1	25
Secondary education	19	76	6	24
OND/NCE	31	67.4	15	32.6
HND/BSc	47	48.5	50	51.5
Post-graduate	6	18.8	26	81.2
Adult secondary	1	100	0	0
Total	107	100	98	100

Table 8: Resilience status in relation to some socio-economic characteristics.

Years of farming experience (years)	Low resilience		High resilience	
	Frequency	Percent (%)	Frequency	Percent (%)
1 - 9	103	68.2	48	31.8
10 - 19	3	7.3	38	92.7
20 - 29	1	8.3	11	91.7
30 - 39	0	0	1	100
Total	107		98	

Source: Author's computation (2023)

Table 9: Distribution of flock size and resilience status of farmers.

Flock size	Low resilience		High resilience	
	Frequency	Percent	Frequency	Percent
At most 500	94	81.1	22	18.9
501 - 5000	13	18.6	57	81.4
5001 and above	0	0	19	100

Source: Author's computation (2023)

Determinants of poultry farmers' resilience to disease outbreaks

Table 10 shows the probit regression result. From the result, the log-likelihood is -41.1571; the likelihood ratio (LR) chi-square test is significant ($p<0.01$). These results affirm that the explanatory variables in the model predicted the outcome of the model effectively. The independent variables considered in the probit regression model were age (years), sex, marital status, years of education, years of poultry farming experience, flock size, membership of association, engagement in other economic activities, and percentage of mortality (last production). Out of the nine independent variables captured in the model, the coefficients of four variables (years of poultry farming experience, flock size, membership of association and engagement in other economic activities) significantly influenced poultry farmers' resilience to disease outbreaks. The percentage of mortality, years of education, marital status, age and sex of farmer were not significant.

Years of poultry farming experience positively influenced the resilience status of poultry farmers ($p<0.01$). The marginal effect reveals that as the years of experience of the poultry

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farmers increase, the probability of the poultry farmers being resilient increases by 6.7%. Feeds and Pullets (2022) submitted that poultry farmers face significant challenges from disease outbreaks, but resilience can be built through proactive measures, good record-keeping, and an understanding local farming systems over the years. Furthermore, flock size had a positive relationship with the resilience status of poultry farmers ($p<0.01$). This implies that as the flock size of a poultry farmer increases, the probability of the poultry farmer being resilient to disease outbreaks increases, particularly when the poultry farmers have invested much capital in re-stocking; they would be proactive in ensuring that all necessary biosecurity practices are put in place to prevent disease outbreaks. The finding disagrees with Biovatec [58] that larger poultry flocks may be less resilient to disease outbreaks, as disease prevalence tends to increase with larger group sizes, while the prevalence within a group tends to decrease. However, Delabouglise et al. (2020) found that while the overall disease prevalence might be lower within a larger flock, the risk of a widespread outbreak is higher. The result also showed that for every poultry farmer that belongs to the Poultry Association of Nigeria (PAN), the probability of being resilient to disease outbreaks increased by 44.7% ($p<0.05$). This may be attributed to the fact that being a member of PAN provides the opportunity for farmers to interact and have access to information and knowledge on possible ways to prevent disease outbreaks. Furthermore, being engaged in other economic activities decreases the probability of a poultry farmer being resilient to disease outbreaks by 86.9%. This may be a result of the less time, attention and care made available for the day-to-day running of poultry farms. This will manifest in the poor supervision of labour.

Table 10: Probit regression result.

Variable	Coefficient	z-value	p-value	Marginal effect
Age of respondent (years)	0.0146 (0.0249)	0.58	0.561	0.0044
Sex	-0.1496 (0.3590)	-0.43	0.67	-0.0446
Marital status	-0.0473 (0.4699)	-0.1	0.92	-0.0141
Years of education	0.0605 (0.0669)	0.88	0.381	0.018
Years of poultry farming experience	0.2258*** (0.0536)	3.31	0.001	0.0674
Flock size	0.0008*** (0.0002)	6.41	0	0.0002
Membership of PAN	1.4973** (0.5092)	2.38	0.02	0.4468
Engagement in other economic activities	-2.9107*** (0.6342)	-3.62	0	-0.8686
Mortality (%)	0.0236 (0.0470)	0.51	0.607	0.0137

Number of observation = 205, LR Chi^2 (9) = 201.48, Prob > chi^2 = 0.0000, Pseudo R^2 = 0.7100, Log likelihood = -41.1571, **, ***represents level of significance = 5 % and 1 % respectively,

Source: Author's computation (2023)

Conclusion and recommendations

The study examined the factors influencing poultry farmers' resilience to disease outbreaks in Oyo State, Nigeria, using a probit regression model. The results showed that years of experience and flock size positively influenced poultry farmer's resilience to disease outbreaks. Experienced farmers are more likely to have built robust knowledge systems and coping strategies that allow them to better manage disease threats. Similarly, farmers with larger flocks are more inclined to invest in preventive measures and biosecurity due to the higher stakes involved. Membership in the Poultry Association of Nigeria also proved to be a significant resilience factor, likely due to the access it provides to vital information, networks, and support systems. Conversely, engagement in other economic activities was found to significantly reduce resilience, suggesting that divided attention and limited time for poultry farm management may lead to poor supervision and vulnerability to disease outbreaks. From the foregoing, the need to encourage peer-to-peer learning and mentorship programs that connect less experienced poultry farmers with veteran farmers is recommended. Extension officers and NGOs can help facilitate knowledge transfer on disease prevention and resilience strategies. Moreover, the role of the Poultry Association of Nigeria in improving farmer resilience should be

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recognised and strengthened. The Federal and State Ministry of Agriculture should partner with the Poultry Association of Nigeria to disseminate timely disease outbreak information and organise regular training. Farmers should be sensitised to the potential trade-offs involved in diversifying into other economic activities. Where diversification is necessary, mechanisms for proper farm delegation and supervision should be developed.

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