POULTRY FARMERS' KNOWLEDGE AND PREVALENCE OF SALMONELLAINFECTION IN RELATION TO HANDLING AND BIOSECURITY MEASURES IN OYO STATE, NIGERIA

Abstract

Poultry-related illnesses, such as Salmonellosis, continue to pose a significant threat to poultry farming in Oyo State, Nigeria. The expenses associated with treating and controlling these diseases tend to raise overall production costs, which in turn reduces the profit margins for poultry farmers.Against this background, this research was devised to identify understanding and incidence of Salmonella infection among poultry farmers as far as handling and bio-security control in Oyo State, Nigeria are concerned.Primary data were collected from 120 poultry farmers using a cross-sectional survey conducted through a multi-stage sampling method and a structured questionnaire. The data were analysed using descriptive statistics and multinomial logit regression. Most of the respondents (77.5%) were aged between 26 and 55 years, with 70.8% being male, 50.8% married, and 85.0% having received formal education.The average years of poultry farming was 15±7.57 years, and 59.2 % of the sample was Yoruba. The findings also demonstrated that all the poultry farmers knew about Salmonella, and over 78.6 % knew the source of Salmonella through seminars, extension workers, family/friends, and the Agricultural Development Programme (ADP) in Oyo State.The study revealed that disease prevention is very relevant in managing poultry diseases, comparable to the impact of medication and insurance. Notably, 62.5% of the poultry farmers were found to engage in low-level disease management practices. It was also demonstrated that key factors influencing the effectiveness of poultry disease control in the area included gender, educational attainment, household size, farming experience, marital status, nationality, ethnicity, and the scale of poultry operations. Based on these findings, the study recommends strengthening extension services and the roles of Agricultural Development Programme (ADP) officers. Additionally, it calls on the government to develop policies aimed at enhancing poultry disease management practices.

Keywords: Poultry; Knowledge; Prevalence; Awareness; Disease Management, *Salmonella*;

Introduction

The agricultural sector stands as the primary contributor to Nigeria's economy, accounting for over 38% of the nation's non-oil revenues. It also employs nearly 70% of the active working-age population.Furthermore, it has been proven that the poultry sub-sector is the most commercialised of all sub-sectors of agriculture in Nigeria (Adene and Oguntade, 2008), and has reshaped the lives of the less privileged individuals of the society through little investment as well as low cost of technology. Its average production is 454 billion tonnes of meat and 3.8 million eggs each year, and the population primarily consists of approximately 180 million birds (FAO, 2018). Animal protein sources in Nigeria, like in most developing economies, are dominated by poultry meat and eggs due to their affordability and acceptability (Bettridge *et al*., 2014; Fagbamila*et al*., 2017). Regrettably, a series of infectious diseases, such as salmonellosis, threatened the sustainable growth of this significant sub-sector. Thus, to the best of our knowledge, there are few published studies of circulating strains of Salmonella in poultry production in Nigeria (Raufu*et al*., 2014; Fagbamila*et al*., 2017), and the risk factors of different types of Salmonella spp. have barely been studied. The populace depends on this industry as the source of nutritional benefits such as animal protein, vitamins, minerals and fats and oils, raw materials to produce organic fertilisers and animal feeds, among others, may be because of low or no distinction against poultry and poultry products and availability and low cost (Fagbamila*et al*., 2010; Bettridge *et al*., 2014). Therefore, the poultry industry has remained pertinent to Nigeria'seconomic development. Poultry-linkedsalmonellosis is widespread throughout the globe, resulting in morbidity and mortality and, hence, financial losses (Akter *et al.*2007; Kwon *et al.*2010; Abiodun *et al.*2014; Ahmed *et al*., 2017).

Salmonella,like most *Enterobacteriaceae*, are motile by peritrichous flagella except *Salmonella pullorum* and *Salmonella gallinarum*, which lack flagella (Bhunia, 2008).Salmonella is categorised into two primary species: *Salmonella enterica* and *Salmonella bongori*.The vast majority of all pathogenic species of Salmonella that affect people encompass the species of *S. enterica*. Over 2,500 serotypes have been reported due to differences in the somatic (O) and flagella (H) antigens (Solari *et al.*, 2003; Barde *et al.*, 2017). However, a recent report from the Centre for Infectious Disease Research and Policy classifies members of the Salmonella species into more than 2541 serotypes (serovars) according to their somatic (O) and flagellar (H) antigens (CIDRAP, 2006). The pathogen lives primarily in the intestinal tract of animals, birds, mice, farm animals, and sometimes in eggs (Ellermeier and Slauch, 2006). The Salmonella-caused disease is significant becauseit is capable of being transmitted to offspringperiodically. The control of salmonellosis in the poultry industry is complex because, in addition to perpendicular transmission from parent stock to offspring, horizontal transmission on farms is also standard; this makes its control a challenge (Dawoud *et al.*2011; Hannah *et al.*2011; Abiodun *et al.*2014). This is possible via infected litter, water, dust, fluff, insects, faeces, feed, equipment, fomites, diseased chicks and rodents, contaminated with Salmonella (Poppe 2000). Other animals, wild birds, and personnel may also transmit them. However, it has been reported that poultry farms and poultry products are the primary sources ofSalmonella contamination (Hussein*et al*., 2009). Studies on numerous poultry diseases occurring in certain parts of the country have shown that salmonellosis is the major threat facing poultry production (Mamman et al., 2014). Additionally, animal droppings have been identified as a potential reservoir for many enteric organisms (Raufu et al.,2013). Hence, consumers of poultry and poultry products are at risk of contracting salmonellosis via consumption of contaminated products (Adesiyun*et al.*2005; Mughini-Gras *et al.*2014).Salmonellasppinfectivity in poultry farms is a common problem of great interest to both the health of the population and the socio-economic life of the country it attacks due to the destruction it can inflict on it.

Furthermore, it has been estimated that the total costs for medical care and lost productivity resulting from food-borne Salmonella infections in humans were between $ 0.6 and $ 3.5 billion annually (CDC, 2009; Majowicz*et al.*, 2010). The other costs linked with Salmonella are factors ranging from direct expenses incurred by producers because ofSalmonella infection in chicken stocks. Preventive measures such as bio-security procedures, facility cleaning and disinfection, rodent management programmes, vaccination, and testing can all significantly add to the cost of production. Moreover, Salmonella contamination of food products can significantly reduce consumer demand and affect producer profits (Namata *et al.*, 2008). One of the biggest and most significant sources of paratyphoid (PT)Salmonellainthe human food supply is through commercial poultry. Controlling paratyphoid (PT) infections has thus become an essential objective for the poultry industry from both public health and economic perspectives (Gast, 2003). In addition, food safety has been studied in depth with everyone's concern of production, transportation, processing, food storage,and food preparation. Nevertheless, despite the amount of knowledge we have, there is still more to unravel about food safety and the complete control of salmonellosis within the poultry industry, with greater structural focus on Oyo State, Nigeria, within the whole farm-to-fork production model. Moreover, Oyo State has also been referred to as an example of a civil servant state due to the large number of civil servants and the existence of thousands of unemployed graduates who find ways to supplement their income. This singular factor has triggered the boom in poultry keeping in Oyo State. The poultry industry in Oyo State, Nigeria, is substantially being impeded by salmonellosis in its pursuit of a private sector facilitated economy and micro stability. Against this, the disease outbreak in the poultry industry is not given a lot of consideration in the team of foresight and preventive measures. Therefore, to prevent Salmonella contamination of broiler/layers, one must be well aware of the most critical risk factors involved in the existence of Salmonella within the poultry production system. Thus, we aim to investigate the knowledge and prevalence of Salmonella spp. infection among poultry farmers in Oyo State, Nigeria, in relation to its handling and biosecurity control.

Materials and Methods

Study area

The research was conducted in Oyo State, Nigeria, situated between latitudes 7°03′ and 9°12′ North of the equator and approximately 2°47′ East of the prime meridian. The region experiences two main climatic seasons.The state is made up of 33 local government areas in four agricultural zones (Ogbomosho zone, Ibadan/Ibarapa zone, Oyo zone, and Oke Ogun zone) and three senatorial districts (Oyo North, Oyo Central, and Oyo South senatorial districts) with a population of 5,591,585 people (National Population Commission, 2006).Oyo State shares its northern border with Kwara State, its southern border with Ogun State, its eastern border with Kwara and Osun States, and its western border with the Republic of Benin. The region's favourable climate has encouraged about 70% of residents to engage in agriculture, cultivating both permanent and food crops. Small-scale farmers make up the majority of the farming population in the state. The population is predominantly Yoruba, speaking the Yoruba language, with a rich cultural heritage and strong kinship ties that unify the community.Climatically, Oyo State experiences a moist equatorial climate characterised by hot, dry, and wet seasons with moderate humidity. The dry season lasts from November to January, while the wet season spans from April to October. Temperatures typically range between 25°C (77°F) and 35°C (95°F) throughout the year. These favourable weather conditions have contributed to the popularity of poultry farming among local farmers (Adeyonu, 2015).Vegetation-wise, the southern part of Oyo State is covered by rainforest, while the northern part features guinea savannah. The south is dominated by dense forests, whereas the north consists mainly of grasslands interspersed with trees.

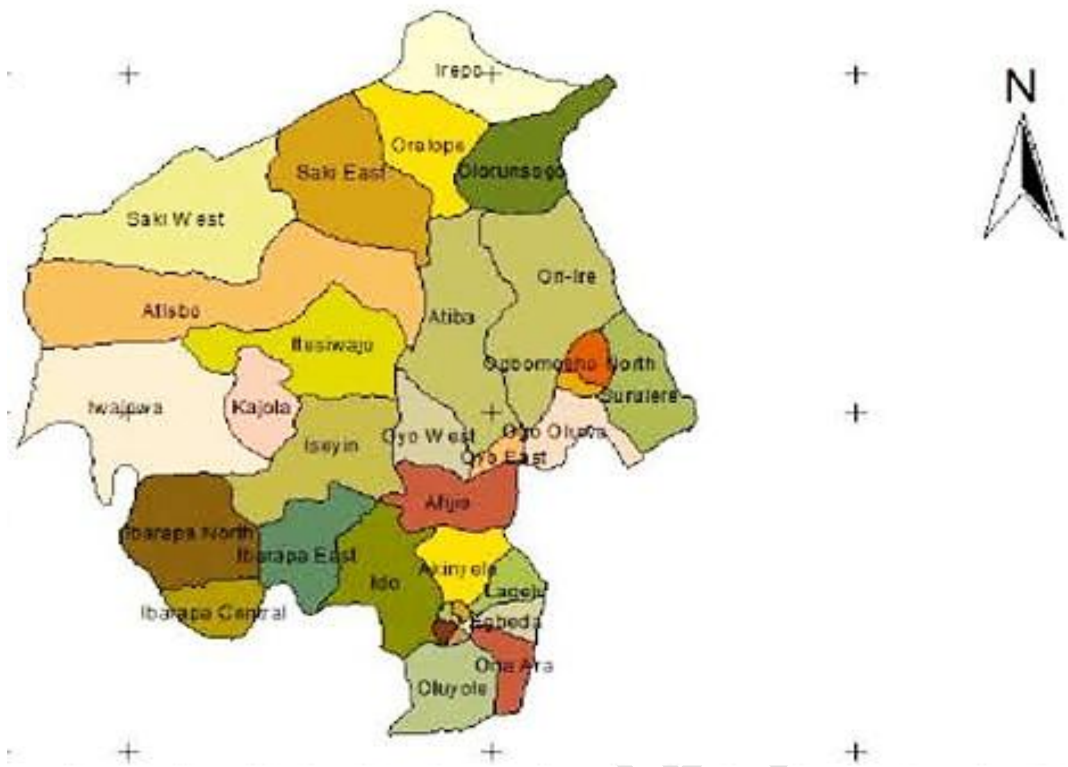

Figure 1: Map showing the thirty-three Local Governments in Oyo State.

Poultry and poultry farm handler sampling

The study, spanning 5 months (July 2021 - November 2021), was conducted on 18 commercial poultry farms. All the farms were sampled twice, and 10 respondents were sampled on each farm, with different respondents per farm comprising attendants, supervisors, security, managers, etc. The participants were requested to read the questionnaire attentively, considering the study topic upon due introduction. A total of one hundred and twenty (120) questionnaires were received at the end of the study and analysed accordingly, as they were found to provide useful data towards the study.

Farm description

Poultry production systems could be categorised into five intermediate categories from the four operational classes of the Food and AgricultureOrganisation (FAO), based on the number of chickensraised in a farm (FAO, 2018). The poultry farms were classified based on size as backyard farms (under 200 birds), semi-commercial farms (200 to 999 birds), small-scale farms (1,000 to 4,999 birds), medium-scale farms (5,000 to 9,999 birds), and large-scale farms (over 10,000 birds). Most of the farms included in this study fell into the medium-scale or large-scale categories. Although grandparent breeds are mainly imported to Europe, wellestablished breeding farms exist in the Oyo State study area in Nigeria.Day-old chicks are likewise mostly produced in the area sampled by the big and small hatcheries and transported by road to different parts of the country in Nigeria (Adene and Oguntade, 2008).

Administration of a structured questionnaire

Study participants and poultry owners were given a structured questionnaire with the required information, which included voluntary and informed consent. The level of poultry disease management was derived from the poultry disease management index as earlier categorisedby Lestari *et al*. (2011) as (1) Low level (0 up to 0.33), (2) Moderate level (0.34-0.66), and (3) High level (0.67-1.0). The three dimensions (Biosecurity practices, Medications, and Insurance) and attributes, as shown in Table 6, were selected using the approach outlined byRitz (2011).

Multinomial logit model

The factors influencing the level of poultry disease management among egg farmers in Oyo State, Nigeria, were analysed using multinomial logistic regression. The dependent variable was the level of poultry disease management, categorised as low, moderate, or high. To estimate the model, one category had to be set as the reference group, which in this case was the least desirable option (low). The model predicts the probabilities of each management level based on the individual characteristics of the poultry egg farmers (Maddala, 1983).With three possible choices (s = 1, 2, 3), the multinomial logit model calculates the probability P_{is} that the i-th poultry egg farmer falls into category$s$. The farmers' characteristics are represented by the vector z. The likelihood of selecting a particular option is determined by the utility of that choice being greater than or equal to the utility of the other alternatives. Following Babcock *et al*. (1995), the multinomial logit model for the three poultry farm categories (s = 1, 2, 3) can be defined as:

$$P(Y = s) = \frac{e^{\beta jz}}{1 + \sum_{j=2}^{s} e^{\beta jz}} \text{ for s not equal to 1} \quad (1)$$

$$P(Y = 1) = \frac{e^{\beta jz}}{1 + \sum_{j=2}^{s} e^{\beta jz}} \quad (2)$$

X_1 to X_{13} represent the independent variables in this study that influenced the level of poultry disease management among poultry egg farmers in Oyo State, Nigeria.The explanatory variables included in the model are similar to those used in previous related studies as earlier outlined by Ojo (2003),Oladeebo and Ambe-Lamidi (2007),Adepoju (2008),Olagunju and Babatunde (2011),Isiorhovoja(2013), Akintunde and Adeoti (2014).

Statistical analysis

Epi Info (version 7.0) was used for data management, Microsoft® Office Excel 2010 Professional Edition for data entry, and SPSS (version 21.0) for data analysis. The data were analysed through descriptive statistics, fuzzy set analysis, and multinomial logit regression.

Result

Socio-demographic characteristics of poultry farmers

Table 1 shows social-demographic indicators of poultry farmers in Oyo State. As a finding, the majority (77.5 %) of the poultry farmers sampled were 26 – 55years of age during the study, and 13.3% of respondents were aged 15-25 years, with a few (9.2 %) above 55years of age. The number of male and female respondents was 70.8 % and 28.2 %, respectively. In addition, just over half (50.8 %) of the poultry farmers were married, 35.8% were single, 6.7% were divorced, and 85.0% of the respondents were of between primary to tertiary level education, with above 59.2 % of poultry farmers practising the Islamic religion or 39.2 % of the poultry farmers practising Christianity with mean years of experience of 15±7.57 years. A total of 50.0 % of the respondents included 6 to 20staff/workers, 31.7 % included 1 to 5 staff/workers, and 18.3 % included more than 20 personnel. Regarding farm capacity, over half (59.2%) of the sampled respondents had a population of less than 25,000 poultry birds, and 29.2% had 25,000-50,000 bird populations at the time of this study.

Table 1: Socio-economic characteristics of the respondents (n = 120).

Variables	Frequency	Percentages (%)
Age		
15-25	16	13.3
26-35	39	32.5
36-45	33	27.5
46-55	21	17.5
Above 55	11	9.2
Sex		
Male	85	70.8
Female	35	29.2
Marital Status		
Single	43	35.8
Married	61	50.8
Divorced	8	6.7
Widowed	3	2.5
Separated	5	4.2
Educational qualification		
No formal education	18	15.0
Primary education	22	18.3
Secondary education	50	41.7
Tertiary education	30	25.0
Religion		
Islam	71	59.2
Christianity	47	39.2
Traditional	2	1.7
Tribe		
Yoruba	71	59.2
Igbo	30	25.0
Hausa/Fulani	13	10.8
Igede	6	5.0
Nationality		
Nigerian	93	77.5

Foreigners	27	22.5
Years of poultry farming experience		
1 – 9	53	44.2
10 – 17	47	39.2
18 – 25	14	11.7
26 – 33	6	5.0
Number of staff/workers		
1 – 5	38	31.7
6 – 10	24	20.0
11 – 15	20	16.7
16 – 20	16	13.3
Above 20	22	18.3
Farm capacity		
Less than 25000	71	59.2
25001 – 50000	35	29.2
50001 – 75000	10	8.3
75001 – 100000	4	3.3

Furthermore, in Table 2, the summary statistics of the respondents show that the mean age was 38.05 years with a standard deviation of 11.66, indicating that the majority were middle-aged with some spread across younger and older groups. The mean sex score was 1.29 (SD = 0.45), which, based on coding, indicates that most of the respondents were male. The average marital status was 1.96 (SD = 0.94), showing that the majority were married, although singles were also represented. For educational qualification, the mean of 2.43 (SD = 1.00) suggests that respondents on average had secondary education, with variations ranging from no formal education to tertiary level. Religion had a mean score of 1.41 (SD = 0.54), indicating that most respondents were Muslims, while a considerable proportion were Christians. The mean tribal code was 1.28 (SD = 0.81), pointing to Yoruba as the predominant ethnic group. The nationality mean of 1.23 (SD = 0.43) reflects that the majority were Nigerians, with foreigners forming a minority. In terms of years of poultry farming experience, the mean was 11.48 years with a standard deviation of 7.05, suggesting substantial experience with wide variation across respondents. The average number of staff employed was 11.24 (SD = 6.64), indicating small to medium farm sizes with variability in workforce. Finally, the mean farm capacity was 26,458 birds with a standard deviation of 18,920, reflecting moderate production capacity overall but with large variation across farms, ranging from small to much larger operations.

Table 2: Summary statistics of continuous variables of respondents (n = 120).

Variable	N	Mean	Std. deviation
Age (years)	120	38.05	11.66
Sex	120	1.29	0.45
Marital status	120	1.96	0.94
Educational qualification	120	2.43	1.00
Religion	120	1.41	0.54
Tribe	120	1.28	0.81
Nationality	120	1.23	0.43
Years of poultry farming experience	120	11.48	7.05
Number of staff/workers	120	11.24	6.64
Farm capacity (birds)	120	26,458	18,920

Awareness and source of information about Salmonellosisinfection.

Table 3 reveals the awareness about Salmonella in Oyo State. Findingsshow that all (100.0%) of the respondents have had Salmonellosis. Majority (90.0%) of the respondents reveals that their staff were observing all necessary protocol against the incidence ofSalmonella infections, while majority (78.6%) of the respondent were aware of Salmonellafrom someone else farm within Oyo State, also, majority (75.0%) of the respondents indicates they have notice sign of Salmonellaspread in their farms and 65.0% of them indicate the incidence of Salmonella in their poultry farms and above half (55.0%) of the respondents were aware of Salmonella disease in the farms.

Table 3: Awareness of Salmonella

Awareness of Salmonella	**Yes (%)**	**No (%)**
Have you heard of a disease called Salmonellosis	120 (100.0)	0(0.0)
Have you noticedanysigns of Salmonellainfection in your farm?	90(75.0)	30(25.0)
Are you aware of the incidence of Salmonellain your farm?	78(65.0)	42(35.0)
If No, are you aware of it in someone else's farms before? **(n = 42)**	33(78.6)	9 (21.4)
Are your farm workers/attendants aware of Salmonella?	66(55.0)	54(45.0)
If yes? Are they observing all necessary protocols against Salmonella? **(n = 66)**	60(90.9)	6(9.1)

Source(s) of information about Salmonellainfection

Figure 2 reveals the source(s) of information about Salmonellainfection, which is based on multiple responses from the respondents sampled. Findings show that the majority (68.3%) of respondents reported that Salmonellawassourcedfrom the seminar. In comparison, 66.7% revealed that Salmonellawassourced from the extension agent, and 64.2% of the respondents revealed that Salmonellawassourced from ADP and family/friends. Other identified sources (s) of information about Salmonella by the respondents were newspapers 55.8%, print media 53.3%, office calls 50.0%, field demonstrations 48.3%, radio and television 46.7% and the internet 44.2 %.

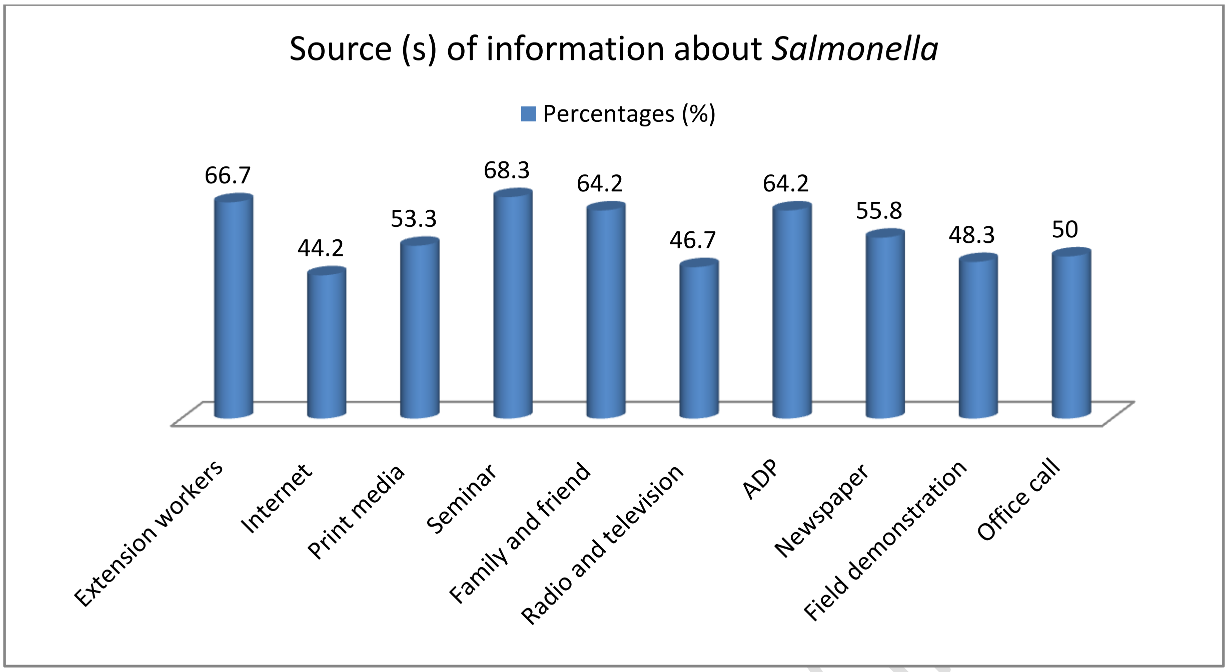

Figure 2: Source(s) of information about Salmonella in the study area.

Figure 3 reveals the age at which the respondents notice chicks with signs of *Salmonella*. Findings show that 36.7% of the respondents indicate no idea at what age they noticed chicks with Salmonella infection in the study area, as at the time of this study. In comparison, 29.2% of the respondents reveal 6weeks – 8weeks, while 15.8% of them indicate below 6weeks, 12.5% of the respondents reveal 9weeks – 11weeks, and 5.8% of the respondents indicates above 11weeks.

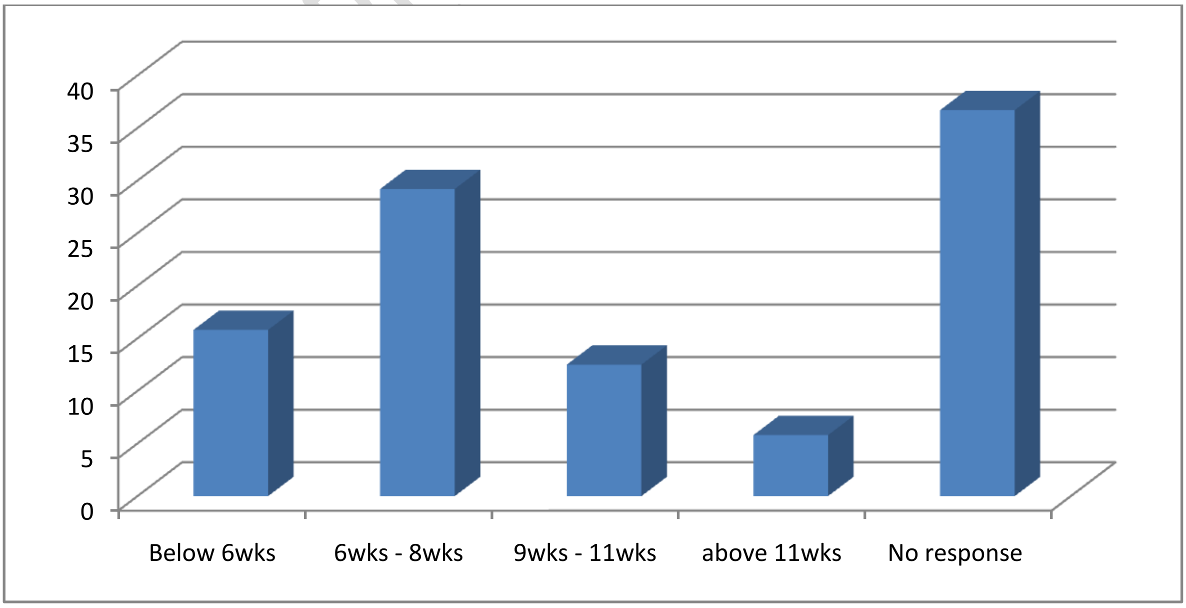

Figure 3: Age at which Salmonellawas noticed by the respondents sampled.

Knowledge of respondents about Salmonellainfection

Table 4 reveals that the majority (88.3%) of the respondents were aware that keeping birds in proximity can cause these diseases in their poultry farms. In comparison,the majority (84.2%) of the respondents sampled also knew that regular feed and water should be ensured to prevent the diseases in the poultry farms, 65.0% of the respondents believed and indicated that vaccination of birds can prevent the spread of Salmonellainfection. Furthermore, the majority (63.3%) of the respondents knew that there is a need to wear personal protective equipment during farm operation, also 60.0% of the respondents knew that wild animals, rodents, and birds must not have access to the pen and feed in the farms. Above half (56.7%) of the respondents recognized that regular vehicle wheel washing is necessary to prevent the spread of Salmonella infection in poultry farms, and 55.8% of the respondents also understood that the source of day-old chicks is another means of transmitting Salmonellainfection. Other notable understanding by the respondents wasthat there is a need for declaration from the hen stock supplier that chicks are free of Salmonella (54.2 %), footbaths filled with treated water should be placed at the entrance of each pen (52.5%) and visitors need to be keep away from the pen house to avoid the spread of diseases (50.8%). More so, knowledge about Salmonella disease was recorded as average, and measures to improve it must be implemented by the respondents sampled in Oyo state, as this will safeguard the farm from unnecessary disease that may arise.

Table 4: Knowledge of respondents about Salmonellosis

Knowledge	**Yes (%)**	**No (%)**
Keeping birds in proximity can cause these diseases	106(88.3)	14(11.7)
The source of stock is a means of transmitting the disease	59(49.2)	61(50.8)
A source of day-old is another means of transmitting the diseases	67(55.8)	53(44.2)
Visitors need to keep away from the pen house to avoid the spread of diseases.	61(50.8)	59(49.2)
Regular feed and water should be ensured to prevent diseases.	101(84.2)	19(15.8)
Vaccination of birds can prevent the spread of diseases.	78(65.0)	42(35.0)
There is a need for a declaration from the hen stock supplier that chicks are free of the Salmonella organism.	65(54.2)	55(45.8)
Footbaths filled with treated water should be placed at the entrance	63(52.5)	57(47.5)

of each pen.		
There should be regular vehicle wheel washing to prevent the spread of disease	68(56.7)	52(43.3)
There is a need to wear personal protective equipment (PPE) during farm operations.	76(63.3)	44(36.7)
Wild animals, rodents and birds must not have access to the pen and feed.	72(60.0)	48(40.0)

Management and prevention of Salmonellainfection

Table 5 reveals the management and prevention of Salmonellainfection in the study area. Finding reveals the mean value bio-security practices as indicated by the respondents sampled, poultry farm must not be located within the lake or pond was with the mean value of (= 2.14). At the same time, each material used should be regularly cleaned and disinfected at all times (= 2.13), poultry farms must be a distance from public roads (= 2.12), and poultry farms and pens must be a distance from one another (= 2.02) in the study area. Furthermore, rodent must be control in the farm to minimise level (= 1.99), each pen should have a separated shoe, cap, boot, cloth etc., to wear during operation and activities (= 1.98), also other livestock animal aside poultry must be control to at least 60m to poultry house(= 1.97) and poultry farm surrounding must be weeded and avoid bushy (= 1.95). Biosecurity practices are routine management strategies aimed at preventing disease outbreaks and unforeseen problems on poultry farms. These measures are readily implemented by farmers at a low cost, unlike medication, vaccination, and insurance, which involve higher expenses. The study's findings also highlight key vaccination protocols considered necessary by the respondents for preventing and controlling Salmonella spread. These include vaccinating birds against diseases previously encountered on the farm (= 2.31), administering the Marek vaccine on day one (= 2.24), applying the Immucox vaccine within the first 1–5 days (= 2.22), giving the first Gumboro vaccine at 8–10 days followed by a second dose a week later (= 2.19), and ensuring proper vaccination of day-old chicks at the hatchery (= 2.18). Other notable prevention measures were a timely interval of routine de-worming (= 2.16), routine use of NDV Lasota every month, frequency of contact with the veterinary doctor (= 2.15), respectively, a timely interval of routine application of antibiotics (= 2.14), and vaccination against Fowl pox at 8 weeks (= 2.13) as prevention and control against Salmonellosisdisease. This will minimise and prevent the problem of disease occurrences in the farms.

Table 5: Management of Salmonellainfection

Management of Salmonella infection	**Always**	**Occasionally**	**Never**	**Mean**
Biosecurity practices (Prevention)				
Poultry farm must be a distance from public roads	41(34.2)	52(43.3)	27(22.5)	2.12
Poultry farms and pens must be at least 100 feet apart from one another	38(31.7)	48(40.0)	34(28.3)	2.03
A poultry farm must not be located within the lake or pond	41(34.2)	55(45.8)	24(20.0)	2.14
The poultry pen must have a gate that restricts vehicle access to the farm	25(20.8)	44(36.7)	51(42.5)	1.78
The Poultry farm must be well-fenced	35(29.2)	40(33.3)	45(37.5)	1.92
Rodents must be controlledon the farm to minimisethe level	33(27.5)	53(44.2)	34(28.3)	1.99
The surroundings of the poultry farm must be weeded and avoid bushy areas	28(23.3)	58(48.3)	34(28.3)	1.95
Other livestock must be controlled to at least 60m fromthe poultry house	28(23.3)	60(50.0)	32(26.7)	1.97
Poultry litter should be taken to the poultry house	22(18.3)	53(43.3)	46(38.3)	1.80
Each pen should have a separate shoe, cap, boot, cloth, etc., to wear during operation and activities	25(20.8)	68(56.7)	27(22.5)	1.98
All materials used should be regularly cleaned and disinfected at all times	34(28.3)	68(56.7)	18(15.0)	2.13
The disinfectantatthe entrance of each poultry house must be ensured	22(18.3)	55(45.8)	43(35.8)	1.83
There should be multiple age groups of birds on the farms	27(22.5)	52(43.3)	41(34.2)	1.88
Medication (prevention and control)				
Birds should be vaccinated for agents known to have caused problems on the farm in the past	59(49.2)	39(32.5)	22(18.3)	2.31
Adequate vaccination of day-old birds should be done at the hatchery	45(37.5)	51(42.5)	24(20.0)	2.18
Application of the Immucox vaccine at 1-5 days	47(39.2)	52(43.3)	21(17.5)	2.22

Application of the Marek vaccine at 1 day old	54(45.0)	41(34.2)	25(20.8)	2.24
Newcastle disease vaccine at one day old chicks must be given	37(30.8)	45(37.5)	38(31.7)	1.99
Vaccination of 1st Gumboro vaccine at 8 – 10 days and 2nd at 1 week after	41(34.2)	61(50.8)	18(15.0)	2.19
Application of Newcastle disease vaccine Lasota at the 2nd and 5th week	44(36.7)	44(36.7)	32(26.7)	2.10
Vaccination against Fowl pox at 8 weeks	46(38.3)	44(36.7)	30(25.0)	2.13
Application of Newcastle disease vaccine Komorov at 12 weeks	36(30.0)	55(45.8)	29(24.2)	2.06
Routine use of NDV Lasota every month should be done	48(40.0)	42(35.0)	30(25.0)	2.15
Timely interval of routine deworming	46(38.3)	47(39.2)	27(22.5)	2.16
Timely interval of routine application of antibiotics	39(32.5)	59(49.2)	22(18.3)	2.14
Delousing of birds must be done	36(30.0)	52(43.3)	32(26.7)	2.03
Frequency of contact with the veterinary doctor	43(35.8)	52(43.3)	25(20.8)	2.15
Regular examination of sick or dead birds	39(32.5)	54(45.0)	27(22.5)	2.10
Insurance of poultry farm (mitigation)	37(30.8)	56(46.7)	27(22.5)	2.08

Categorisation of management of Salmonellainfection

The management of poultry diseases, particularly Salmonella widespread, was classified into three categories: (1) Low level (0.00–0.33), (2) Moderate level (0.34–0.66), and (3) High level (0.67–1.00). According to Table 5, the majority of poultry farmers (62.5%) fall within the low-level management category, 25.0% practice moderate-level management, and 12.5% operate at a high level (Table 6).

Table 6: Distribution of the level of poultry disease management (i.e*Salmonellaspp*widespread)

Poultry diseases	Management level	Frequency	Percentages (%)
Low	0.0 – 0.33	75	62.5
Moderate	0.34 – 0.66	30	25.0
High	0.67 – 1.0	15	12.5
Total		**120**	**100.0**

Strategies implemented for controlling Salmonellainfection widespread in the poultry farm and the environment

It was shown that 80.0 % of the respondents indicated regular hand washing as a good strategy to be implemented in controlling Salmonellosisdisease. In comparison,75.9% of the respondents sampled also suggest that proper preparation of poultry feed is a good strategy to implement in controlling Salmonellosis in poultry farms. 68.3% of the respondents believe and indicate that a good water source can prevent the spread of Salmonellainfectionif implemented. Furthermore, 65.0 % of the respondents indicate that regular vaccination of birds and the environment is a good strategy to be implemented in controlling Salmonellosis disease, 64.2% of them indicate that general cleaning of the farm environment, and 63.3% of them also indicate that personal (body) hygiene is a good strategy to be implemented in controlling Salmonellosis. Others were proper disposal of waste, regular screening of people visiting farms, reporting to the veterinary clinic when birds are sick, and appropriate monitoring and evaluation of poultry farms (Table 7).

Table 7: Strategies implemented in controlling Salmonellaspp in the poultry farm and environment.

Preventive and control measures of Salmonellainfection by the respondents	**Yes(%)**	**No (%)**
Regular hand washing	96(80.0)	24(20.0)
Personal (body) hygiene	76(63.3)	44(36.7)
Reporting to the veterinary clinic when birds are sick	69(57.5)	51(42.5)
Good water source	82(68.3)	38(31.7)
Proper preparation of poultry feed	91(75.8)	29(24.2)
Regular screening of people visiting the farm	71(59.2)	49(40.8)
General cleaning of the farm environment	77(64.2)	43(35.8)
Regular vaccination of birds and the environment	78(65.0)	42(35.0)
Proper monitoring and evaluation of farms	60(50.0)	60(50.0)
Proper disposal of waste	72(60.0)	48(40.0)

Factors influence the level of poultry disease management

The overall adequacy of the model was confirmed using the Chi-square test, which was statistically significant at the 1 % level ($\chi^2 = 102.45$, $p = 0.0001$), indicating a strong fit for the data. The marginal effects analysis revealed several key factors influencing poultry disease management levels among farmers. The sex of the respondent had a notable impact; female poultry farmers were 21 % less likely to achieve a moderate level of disease management compared to their male counterparts. This suggests that female farmers are less likely to implement moderate disease control practices. Education showed a positive relationship with disease management. For each additional year of formal education, the probability of attaining a moderate level of disease control increased by 1 % compared to a low level. This implies that higher educational attainment enhances the likelihood of adopting effective and modern disease management practices. More so, the household size also played a significant role, where an increase in household members was associated with a 13 % rise in the probability of achieving moderate disease management. Similarly, each additional year of poultry farming experience increased the likelihood of moderate disease control by 2%. These findings are consistent with the study by Ezeh *et al*. (2012), which suggested that more farming experience enhances a farmer's ability to manage disease outbreaks effectively.

Furthermore, marital status was found to raise the likelihood of achieving moderate disease management by 11 %. Also, the farmer's nationality and ethnic background (tribe) increased the chances of reaching a moderate level of disease control by 23 % and 25 %, respectively. Farmers who are Yoruba-speaking natives of the study area were more likely to possess better knowledge and practices for disease prevention compared to non-natives. Farm capacity was also a significant predictor, larger-scale operations had a 21 % higher likelihood of achieving moderate disease management compared to smaller farms. In terms of achieving a high level of disease management, being female slightly reduced the probability by 2 %, while a larger household size increased it by 6 %. An additional year of farming experience marginally raised the likelihood of high-level disease control by 0.3%. Moreover, both nationality and farm capacity contributed to a 10 % increase in the likelihood of reaching a high level of disease management compared to a low level.

Table 8: Results of the multinomial logit model of determinants of the level of poultry disease management

Explanatory variables	Marginal effect	Std. error	t-value	Marginal effect	Std. error	t-value
Age	-0.3421	0.2151	-0.453	-0.1261	0.3971	-1.602
Sex	-0.2159**	2.1412	-2.326	-0.0264**	0.1127	-0.167
Educational level	0.0148**	0.3823	1.324	0.0072	0.0013	0.079
Household size	0.1356**	0.2814	0.874	0.0643*	0.0112	1.178
Hired labour	-0.0003	0.0453	-0.321	0.0732	0.0033	2.187
Poultry farm experience	0.0244*	0.1417	0.645	0.0033**	0.0132	0.433
Marital status	0.1102**	0.3216	2.254	0.1224	0.0094	1.704
Nationality	0.2373*	0.5365	1.382	-0.1017*	0.1014	-1.346
Tribe	-0.2564**	0.1563	0.237	0.0429	0.1142	0.355
Poultry system	0.2026	0.4212	0.443	- 0.1627	0.0624	-1.052
Farm capacity	0.2138**	0.1021	-0.253	0.1008*	0.3121	0.353
Age of birds	0.0023	0.0641	0.243	0.0023	0.0124	0.178
Mortality rate (%)	0.2543	0.1034	1.462	0.0033	0.0157	0.135

*Significant at 10%, **Significant at 5%, ***Significant at 1%, No. of obs = 120 LR χ^2 = 102.45 Prob>χ^2 = 0.0001, Log likelihood = -112.2302 Pseudo R^2 = 0.1014.

Discussion

Most of the poultry farmers surveyed were within their economically active age group. They were relatively young, making them more likely to adopt innovations that could enhance poultry production in Oyo State, Nigeria.The outcome suggested that contemporary poultry farming remains a male profession rather than a female occupation, still likely due to the nature of the risk that is involved, labor-intensive, as well as the other activities that are involved in farm husbandry are not favourable to most women. This finding aligns with earlier studies by Lawal *et al.* (2009), Adisa and Akinwumi(2012),and Uzokwe and Bakare (2013). Nevertheless, 35.8 % of the participants were still unmarried, with 85 % having a formal education. In terms of worshipped religions, Islam and Christianity are the main dominantreligions, as 77.5% of the sampled respondentsareNigerians. Most of the poultry farmers (83.4 %) were experienced in poultry farming,with a maturity of 1-17 years.This is anticipated to contribute to improved disease management, as greater years of experience in poultry farming generally equip farmers with better exposure and skills, making them more effective in preventing and managing poultry diseases.The present study findingsshow that insecure practices of disease prevention had a high relative contribution to disease management as compared to medications and insurance. However, this is because bio-security practices are normal business practices that the poultry farmers are performing easily, which does not incur high cost as compared to medication and insurance. This observation is in contradiction to the results that were obtained by Obi *et al*. (2008), who found that poultry production in Nigeria is largely backyard poultry production with insignificant or no bio-security, as opposed to minimal or moderate bio-security of peri-urban and urban commercial poultry production.The respondents' knowledge of salmonellosis was evaluated through their awareness of its prevention and control measures in poultry farms, along with their ability to recognize the disease's symptoms.In the majority of cases, it became evident that the diseases of salmonellosis are unfamiliar to most farm handlers. This could be attributed to their low level of education and exposure to related issues, which indicates a lack of awareness of the disease (Agada *et al*., 2014). This, nevertheless, could have been due to the high rate of prevalence that some poultry farms had been reported to have. In addition, the lack of knowledge has also increased the risk of exposure and transmission of Salmonella spp.from farm handlers to flocks, as reported by several studies (Charles and Takayuki, 2010; Mai et al., 2013), especially with the recent surge in poultry farming business in Jos.Salmonellosis is considered one of the most significant bacterial disease challenges facing the global poultry industry.Salmonellaspecies are responsible for a variety of acute and chronic diseases in both poultry and humans (Majowicz*et al*., 2010; Okwori*et al*., 2013). Infected poultry products are among the most significant sources offoodborne outbreaks in humans. Our study revealed that the hygienic practices of poultry farmers did not meet the hygiene standards for handling meat products as recommended by the World Health Organisation and the Food and Agriculture Organisation Joint Committee (Codex Alimentarius Commission, 2005).

Poultry feed accounts for the most significant proportion of production costs in both Oyo State and Nigeria as a whole.The feed is commonly mixed with animal constituents like egg shells, blood meal, fish meal, and bone meal. Soybean cake and groundnut cake, which are plant-based sources of protein and calcium, are commonly used in animal feed. However, improper preservation, storage, and packaging of these ingredients often lead to contamination risks in poultry feed.As noted by Jones and Richardson (2004), the climatic weather in Nigeria consists of warm and humid conditions, and Salmonella organisms can, under these circumstances, multiply in the feed, especially during farm storage and administration. Importantly, contamination can also occur during the processing, transportation, and distribution of poultry feed. In an effort to reduce costs, many farmers either prepare feed themselves on the same premises where birds are kept or source it from local feed mills with poor hygiene standards. Thesepracticesheighten the risk of disease outbreaks.This high variety of ingredients used to produce poultry feed, as well as the high level of diversification among the farms in the feed production and processing and the general low level of hygienic practices can explain the high prevalence of Salmonella in feed samples and the heterogeneity of serovars isolated from this source (Fagbamila*et al.*, 2017).

The outcome of this research has shown that the importance of bio-security practice (disease prevention) by poultry farmers in disease management is ranked very close to medication and insurance within the study region. This actually shows that bio-security measures are a normal managerial practice that is practised readily by the poultry farmers with minimum cost incurred as compared to medication and insurance, which requiresa high cost. The application of standard biosecurity measures is vital in protecting poultry birds from any disease, as demonstrated by Dorea *et al*. (2010). However, biosecurity has focused on maintaining or improving the health status of animals and preventing the introduction of new disease pathogens by assessing all possible risks to animal health (Fraser *et al*., 2010; Julien and Thomson, 2011). Augustine *et al*. (2010) reported that the implementation of sound bio-security measures will go a long way in minimising the problems of disease outbreak and spread in the Nigerian poultry industry, and also maintain consumers' confidence in Nigerian poultry products. Nevertheless, evidence gathered showed that there is a diverse urgency to sensitise the poultry farmers on the need to adopt good hygienic practices and sanitary measures in an effort to contain the spread of Salmonella. Aside from resource constraints, several measures are suggested to limit vertical and horizontal transmissions of *Salmonella* on farms and make the birds less vulnerable to Salmonella, as noted by some scholars (Humphrey, 2006; Wales *et al*., 2007; Ishihara *et al*., 2009).Specifically, to ensure feed and water remain free from *Salmonella* contamination, farms must implement effective cleaning and disinfection practices, establish strong protective measures against both inanimate and animate vectors, and enhance the overall hygiene and sanitary conditions of the poultry environment.

Conclusion

The outcome of this research indicates that the poultry farming industry is predominantly male, and the farmers were active, agile and within productive age ranges; they were well-educated with significant formal education and possessed considerable poultry farming experience. Moreover, the study populations demonstrated a high awareness ofSalmonellosisdisease, including its signs, symptoms, past occurrences, and preventive measures. In addition, key information sources for Salmonellosis disease were identified as seminars, extension workers, family/friends, and the Agricultural Development Programme (ADP), with most study participants being well-informed about disease prevention. However, the findingssuggested that biosecurity practices significantly influence poultry disease management in Oyo State, Nigeria. Nevertheless, most farmers practiced low levels of disease management, with only a minority achieving moderate or high levels. Positive factors associated with moderate disease management, compared to low levels, included years of formal education, household size, and poultry farming experience, whereas the farmer's sex had a notable negative effect. In addition, marital status, nationality, tribe, and farm capacity were important determinants of disease management levels.

Recommendations

In light of the study's findings, the following recommendations are suggested:

1. The point of policy focus must be directed towards the enlightenment programmes on the importance of bio-security as a very important aspect of managing poultry disease within the study region, or indeed to the whole country.
2. It should be required that the extension agency spread better bio-security measures and better medication methods to all poultry farmers,which will enhance the current level of poultry disease control in the study area.
3. Furthermore, it is stipulated that the government ought to educate poultry farmers regularly with reference to biosecurity, disease reactions, and integration of current husbandry-grazingpractices, which will protect our livestock sector.
4. Poultry farmers in the southwest of Nigeria have a very low mitigation option utilisinga livestock insurance policy. Consequently, the government should implement

a policy that increases subsidies on livestock insurance to make it more affordable for poultry farmers.

5. Lastly, educating poultry farmers and raising awareness about the advantages of livestock insurance through extension agents is vital to boost their engagement in using insurance as a tool to manage the risks associated with disease outbreaks in poultry farming.

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