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Prevalence of *Salmonella* outbreak in poultry farms: a comparative study of Osun and Ogun States, Nigeria

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A B S T R A C T

The study describes farm management practices, determines farmers' knowledge of *Salmonella*, and identifies agricultural extension advisory services available to strengthen livestock farmers to examine the prevalence of *Salmonella* outbreaks among poultry farms in Osun and Ogun, Nigeria. The study utilized a cross-sectional survey of 240 poultry farmers and 60 agricultural extension workers from both states. Data was collected with an interview schedule and analysed using percentages, frequency count and mean. Results indicate that the majority (68.3% and 67.5% in Osun and Ogun States, respectively) of the respondents were males; the mean age of the respondents was 47 years and 46 years in Osun and Ogun States, respectively. High (100.0% and 78.3%) *Salmonella* disease outbreaks were experienced in Osun and Ogun, respectively. Semi-intensive and intensive production systems are the predominant production methods in both states. The results further reveal that 56.7% and 70.0% of respondents in Osun and Ogun states had over 15 years of regular contact with extension services, respectively. However, the majority (83.3% and 91.7%) of Extension agents in Osun and Ogun states were knowledgeable about the *Salmonella* infection. The study concluded that for better adherence against disease outbreaks in poultry farms, monitoring and evaluation of all advisory services rendered should be done to ensure compliance. It is therefore recommended that there be improved biosecurity practices across the study location and adequate extension services that will enhance biosecurity measures and training to mitigate *Salmonella* outbreaks in poultry farms in the study area.

Keywords: *Salmonella*, Poultry, Farms, Biosecurity, Zoonotic diseases

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Introduction

Poultry production is essential for global food security by providing economical and high-quality protein through meat and eggs (Abbas, 2020). However, the presence of pathogens of zoonotic origin, like *Salmonella* causes serious damage to both public safety and poultry health (Farooq *et al.*, 2024). The infection may lead to huge economic losses to farmers due to reduced production and high mortality, whilst contaminated products (eggs and meat) serve as a major route for Salmonellosis in humans (Khan *et al.*, 2023).

The Nigerian poultry sector has expanded rapidly in recent years. Local production only meets 30 percent of the demand for chicken eggs and meat. Thus, there is huge scope for the industry to expand. Nigeria has the largest annual egg production and the second-largest chicken population in Africa. The Nigerian poultry industry comprises about 180 million birds, of which 80 million chickens are raised in extensive systems, 60 million in semi-intensive, and 40 million in intensive systems. Poultry production in Nigeria amounts to up to 300 metric tons of meat and 650 metric tons of eggs annually. About 85 million Nigerians are involved in poultry production (many on a small to medium scale) (FAO, 2019).

Salmonella is one of the major zoonotic pathogens that affect poultry farms globally, with significant economic implications due to its impact on poultry health, which usually affects humans because of poultry meat consumption. In Nigeria, the poultry industry is a critical component of the agricultural sector, providing employment and contributing to food security. However, the incidence of *Salmonella* poses a severe threat to both animal and public health, particularly in regions like Osun and Ogun states, where poultry farming is widespread. *Salmonella* is a significant pathogen in poultry (Majowicz *et al.*, 2010). The prevalence of *Salmonella* outbreaks in poultry farms has emerged as a critical issue in the agricultural and public health sectors worldwide.

The agricultural sector continues to be the most prominent supporter of Nigeria's economy, generating more than 38% of non-oil foreign exchange earnings and providing employment for approximately 70% of the country's active labor force. The poultry sub-sector stands out as the most market-oriented segment of Nigeria's agriculture (Adene and Oguntade, 2008), significantly improving the livelihoods of the less privileged with minimal investment and affordable technology. It produces an average of 454 billion tonnes of meat and 3.8 million eggs annually, supported by a population of 180 million birds (FAO, 2018). In Nigeria, poultry meat and eggs serve as primary sources of animal protein due to their cost-effectiveness and widespread acceptance (Bettridge *et al.*, 2014; Fagbamila *et al.*, 2017). However, the sustainable progress of this vital agricultural sector is increasingly threatened by infectious diseases, particularly those caused by *Salmonella*.

Currently, limited published research exists on the common species of *Salmonella* in Nigeria's poultry systems (Raufu *et al.*, 2014; Fagbamila *et al.*, 2017; Mshelbwala *et al.*, 2017). A significant gap exists in comprehending the risk factors associated with the various *Salmonella* serotypes. Poultry, one of the most consumed protein sources globally, is crucial to food security. However, the intensification of poultry farming has inadvertently facilitated the proliferation of *Salmonella*, leading to frequent outbreaks that compromise food safety and public health. According to O'Bryan *et al.* (2022). Poultry accounts for 17.9% of all foodborne sicknesses, with *Salmonella enterica* responsible for 19% of those linked to poultry. Similarly, IFSAC (2017) opined that 14% of *Salmonella* outbreaks are associated with chicken. Notably, both studies based their estimates on outbreak data to extrapolate illness cases by pathogen and food source.

Salmonella is a genus of bacteria known to cause salmonellosis, a disease characterized by gastrointestinal symptoms such as diarrhoea, fever, and abdominal cramps. *Salmonella* infections can range from mild to severe and may be fatal among vulnerable groups like children, the elderly, and immune-compromised individuals. Environmental changes driven by climate change significantly affect the transmission and persistence of zoonotic pathogens, influencing over half of communicable diseases (Morgado *et al.*, 2021; Mora *et al.*, 2022; Dietrich *et al.*, 2023). For *Salmonella*, a key zoonotic agent, ambient temperature plays a critical role at various stages along the food chain. In the United States, ready-to-eat seafood has been identified as a notable contributor to *Salmonella* outbreaks (Ehuwa *et al.*, 2021). A link between *Salmonella* outbreaks and rising outdoor temperatures has been recognized for some time (Akil *et al.*, 2014; Zhang *et al.*, 2018). Environmental issues like precipitation, humidity, soil composition, and pH levels also influence the pathogen's transmission, replication, and survival (Dietrich *et al.*, 2023; Robinson *et al.*, 2022). Poultry farms are recognised as significant reservoirs of *Salmonella*, with the bacteria often present in the intestines of healthy birds, thereby contaminating the environment, feed, water, and, ultimately, the poultry products intended for human consumption (Galán-Relaño *et al.*, 2023). Various factors, including farm management practices, biosecurity measures, and environmental conditions, influence the prevalence of *Salmonella*. In regions with intensive poultry farming, such as South-West Nigeria, the risk of *Salmonella* outbreaks is heightened due to the high density of poultry populations, inadequate sanitation, and suboptimal biosecurity practices.

Agricultural extension and advisory service is a structure that enables access of farmers to new knowledge, technologies, and information and promotes research, education, agri-business, and other relevant institutions to assist them in developing their own organizational, technical, and management skills and practices for better productivity. Different agricultural extension services exist worldwide to facilitate learning, teaching, and extending new knowledge and technologies in non-formal educational settings, improve farm productivity and increase farmers' incomes. The existing public agricultural extension service in Nigeria is characterized by many shortfalls, such as grossly inadequate and untimely funding; a fragile research-extension-farmer-inputs linkages system; top-down, supply-driven extension approaches; and poor targeting of women, youths, and vulnerable groups, among

others (Osondu *et al.*, 2015; World Bank, 2020). Extension service varies by country in nomenclature. In Nigeria, the forefront workers are agricultural extension workers, extension officers, extension educators, livestock development officers, fishery technicians, and community forestry and natural resources management officers. The livestock development officers or extension service delivery system, encompassing competent and well-trained personnel, among other requisites, are required to improve the development of the livestock sub-sector in the study area. The necessity for increased uptake of improved livestock production approaches by livestock farmers has long been recognized as a panacea for a virile livestock subsector in Nigeria. One of the challenges for poultry farmers with livestock diseases is *Salmonella*.

The economic impact of *Salmonella* outbreaks in poultry farms in the study location is significant. Outbreaks can lead to substantial financial losses due to the culling of infected flocks, decreased productivity, and the cost of implementing control measures. In addition, outbreaks can lead to trade restrictions, as countries impose bans on importing poultry products from regions affected by *Salmonella*. Control measures to reduce the prevalence of *Salmonella* in poultry farms are essential to protect both animal and public health. These measures include implementing strict biosecurity practices, such as regular cleaning and disinfection of poultry houses, controlling farm access, and ensuring that feed and water are free from contamination. Vaccination of poultry against *Salmonella* is also a critical strategy, as it can significantly reduce the bacterial load in flocks, thereby minimizing the risk of transmission. Livestock extension workers must be trained to monitor and survey *Salmonella* infection in poultry birds with adequate control measures. Monitoring and surveillance of *Salmonella* in poultry farms are vital to an effective control strategy. Regular testing of poultry flocks, feed, water, and the farm environment can help in the early detection of *Salmonella*, enabling timely intervention to prevent outbreaks. Using molecular techniques has improved the capability to spot and trace *Salmonella* strains, allowing for more targeted and effective control measures. This study aims to assess the prevalence of *Salmonella* outbreaks in poultry farms across these two states, examine the types of birds most affected, evaluate the awareness and management practices among poultry farmers, and determine the issues and implications of extension advisory services among livestock farmers related to *Salmonella* disease outbreaks.

Methodology

Description of the study areas (Osun and Ogun State)

Osun State, located in southwestern Nigeria, comprises 30 Local Government Areas and has an estimated population of 3.4 million. It covers a land area of approximately 14,875 km², lying between latitudes 5°N and 8°N, and longitudes 4°E and 5°E. The state experiences a humid tropical climate, with a mean annual temperature of around 28°C and average annual rainfall exceeding 1600 mm. Rainfall distribution varies across the state, ranging from 1200 mm to 1800 mm in the southern region during peak rainfall, and between 800 mm and 1500 mm in the northern areas. The broader regional climate features average temperatures between 24°C and 25°C, within a wider geographical zone spanning latitudes 3°N to 5°N and longitudes 7°E to 9.3°E. Ogun state comprises four socio-cultural zones (Agbaje *et al.*, 2021) spread across 20 Local Government areas. Ogun State covers an area of 16,762 square kilometers and stands at an elevation of 169 feet with a population of 4,054,272. Ogun State occupies latitude 6.2–7.8°N and longitude 3.0–5.0°E. The two states are major in agriculture, with a large population involved in poultry farming. The states fall within two primary ecological zones: the rainforest and the derived savannah. Major crops cultivated include yam, cassava, maize, rice, various vegetables, and cash crops such as cocoa, rubber, kola nut, and citrus. In addition to crop production, farmers in the study areas also rear livestock, including sheep, goats, local chickens, and pigs. Furthermore, the intensive rearing of exotic poultry breeds—such as cockerels, layers, and broilers—has gained popularity in recent years.

Study population

The study population comprises poultry farmers and extension agents across the two states (i.e., Osun and Ogun states).

Sampling procedure

A cross-sectional survey was conducted in 2021 among poultry farmers in Osun and Ogun states, Nigeria. A multistage sampling technique was used to select respondents for this study. In the first stage, three local government areas (LGAs) in Osun and Ogun States were randomly selected for the study. In the second stage, twelve commercial layer poultry farms in the two states were sampled; two from each of the three LGAs were purposively recruited based on the presence of commercial layer production and farmers' consent. The three LGAs selected in Ogun state are Odeda LGA, Ijebu-Ode LGA and Yewa North LGA. For Osun state, Ilesha West LGA, Osogbo LGA and Ife East LGA.

Overall, one hundred and twenty (120) poultry farmers were selected from each state, making a total of two hundred and forty (240) poultry farmers selected from the two states. Also, ten (10) extension agents (EAs) were sampled from each of the three LGAs across the two states, purposively based on the involvement with livestock farmers in the study location, making a total of sixty (60) EAs across the two states. The total sample size for this study was two hundred and forty (240) poultry farmers and sixty (60) EAs across the two states.

Data collection procedure and analysis

Data for this study were collected through the use of structured questionnaires covering demographic information, *Salmonella* knowledge, farm management practices, extension advisory service and poultry farmers' disposition to extension advisory service. The data collected were analyzed using descriptive statistics such as frequency count, percentages, mean and presented as tables.

Ethical considerations

The Animal Care and Use Research Ethics Committee (ACUREC), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, and Department of Infectious Disease and Environmental Hygiene in Livestock, Institute of Animal Science, Faculty of Agriculture University of Hohenheim, Stuttgart, Germany reviewed and approved the protocols of the study (FUNAAB and IEAHFAUHSE/11/0112). Verbal informed consent was obtained from all farm owners prior to the commencement of the study.

Results and Discussion

Demographic characteristics of poultry farmers

Results in Table 1 revealed the biodata of sampled farmers from the study. The average farm capacity was computed at 14,685 square feet in Osun and 100,000 square feet in Ogun states. Most of the people interviewed are farm attendants (33.3%) across the study areas. The mean age of the respondents was 47 years in Osun and 46 years in Ogun state, respectively. The majority (68.3% and 67.5%) of the respondents were males, which constituted the significant respondents in the Osun and Ogun states, while more than half (57.5%) were married across the two states. Moreover, most of the respondents (49.2%) have secondary school education as their highest level of education, practice Islam as a religion and are Yoruba by tribe (61.7%). The majority (85.8% and 85.0%) of the respondents sampled in Osun and Ogun are Nigerians who, on average, have 11 years of work experience in poultry farming.

Table 1. Demographic Characteristics of Respondents.

Variables	Response	Osun State (%)	Ogun State (%)
Farm capacity	Mean farm capacity	14,685	100,000
Correspondent status	Owner	28(23.3)	29(24.2)
	Manager	35(29.2)	34(28.3)
	Attendant	40(33.3)	40(33.3)
	Others	17(14.2)	17(14.2)
Age	Mean age	47	46
Sex	Male	82(68.3)	81(67.5)
	Female	38(31.7)	39(32.5)
Marital status	Single	46(38.3)	46(38.3)
	Married	69(57.5)	69(57.5)
	Divorced	5(4.2)	5(4.2)
Educational Qualification	No formal education	18(15.0)	18(15.0)
	Primary education	24(20.0)	24(20.0)
	Secondary education	59(49.2)	59(49.2)
	Tertiary education	19(15.8)	19(15.8)
Religion	Islam	70(58.3)	71(59.2)
	Christianity	48(40.0)	47(39.2)
	Traditional	2(1.7)	2(1.7)
Tribe	Yoruba	74(61.7)	74(61.7)
	Igbo	30(25.0)	30(25.0)
	Hausa/Fulani	16(13.8)	16(13.3)
Nationality	Nigerian	103(85.8)	102(85.0)
	Foreigner	17(14.2)	18(15.0)
Years of experience	Mean years of experience	10.94	11.38
No. of staff/workers	1 – 5	27(22.5)	38(31.7)
	6 - 10	26(21.7)	24(20.0)
	11 - 15	27(22.5)	20(16.7)
	16 - 20	17(14.2)	16(13.3)
	Above 20	23(19.2)	22(18.3)

n = 240, Source = Field Survey (2021)

Knowledge of Salmonella

In Osun, all respondents (100%) had heard of *Salmonella*, while in Ogun, 78.3% were aware of the disease. Extension workers were the primary source of information in Osun, whereas family and friends were more influential in Ogun State. Awareness of *Salmonella*'s incidence on farms was similar across both states, with around 62.5% of respondents reporting knowledge of outbreaks. Respondent's knowledge of *Salmonella* was ascertained in Table 2, where all (100%) were in Osun state, and the majority (78.3%) in Ogun state was affirmed to have heard of *Salmonella* disease. Most (85.8%) of the respondents in Osun state heard about *Salmonella* disease through extension workers, and 62.5% heard about the disease through family and friends in Ogun state. Across the two states, 62.5% of respondents affirmed being aware of the incidence of *Salmonella* and its prevalence on someone's farm. Most (30.0%) of the chicks with *Salmonella* disease were between 6 weeks and 8 weeks in Osun and 28.3% in Ogun state. More than half of the farm workers across the study areas (55.0%) were aware of the *Salmonella* disease, and 39.2% observed protocols against the disease. As indicated by most respondents, the above (52.5% and 53.3%) in Osun and Ogun states reveal that *Salmonella* is prevalent in the rainy season. Furthermore, the disease has no economic importance across the states, as indicated by the majority (79.2%). Most (56.7%) of the respondents' farms do not have a policy restricting access to the farms, and 55.0% do not delay visitors for 48-72 hours between visits.

The study's findings further revealed that in most of the farms, 53.3% maintained a vehicle wheel wash for visitors, most (74.2%) maintained footbaths filled with sanitizer and 67.5% maintained hand washing facilities across the study areas. In many farms, 55.0% do not have an ante-room facility. However, most of the respondents, 64.2%, affirmed that visitors wear personal protective equipment (PPE) before entering the farms. Furthermore, most (60.8%) respondents indicated that workers and visitors change their clothes between pen houses. Wild animals and birds have access to pens and feed, as indicated by most respondents (55.0%), and an even indication among respondents 60(50.0%) revealed that rodents have access to poultry pens across the states. However, as revealed by 64.2% of the respondents, domestic pets have access to poultry and other livestock kept on the poultry farm, as indicated by most respondents (72.5%) and (60.0%) accordingly. It is noteworthy that most of the respondents (65.8%) in Osun and (61.7%) in Ogun states disposed of dead birds, and most staff (61.7%) in Osun state and (73.3%) in Ogun state are trained in *Salmonella* control. The two states are unindustrialized and may probably have the same level of exposure based on vision for infectious disease control measures. The poor knowledge of transmission, control, and prevention of *Salmonella* infection agreed with other studies (Smith *et al.*, 2010; Jennifer, 2013). However, a slightly higher knowledge score was reported in another related study (Varga *et al.*, 2013). Good food safety and hygiene knowledge could contribute to positive attitudes toward preventing *Salmonella* infection, taking appropriate actions and seeking medical care if a food handler has infectious diarrheal disease.

Farm management practices

Table 3 shows information about general farm management in Osun and Ogun states. The majorities (73.3%) of the respondents in Osun state have a semi-intensive production system, and 53.3% have an intensive type of production system in Ogun state. Most respondents (73.3% and 61.7%) reared layers and broilers on the Osun and Ogun state farms, respectively. Above half (50.8% and 50.0%) of them kept farm records of disease outbreaks. It was noted that 55.0% and 42.5% of respondents in Osun and Ogun states have visitors' records. Most (61.7%) respondents and 44.2% in Ogun and Osun states affirmed that other animals are kept near birds on their farms. Hired labour was the primary type used on farms in Osun (81.7%) and Ogun (75.0%), as indicated by the respondents; deep litters and cage systems were the significant rearing styles practiced in Osun and Ogun states, as indicated by most respondents, (50.8%) and (45.0%), respectively.

Table 2. Knowledge of *Salmonella* among respondents (n =240).

Variables	Response	Osun State (%)	Ogun State (%)
I heard of a disease called *Salmonella*.	Yes	120(100)	94(78.3)
Sources of information about *Salmonella*.	Extension worker Internet Print media Seminar Family and friend Radio and television ADP Newspaper Field demonstration Office call	103(85.8) 64(53.3) 72(60.0) 71(59.2) 83(69.2) 56(46.7) 71(59.2) 65(54.2) 63(52.5) 57(47.5)	61(50.8) 53(44.2) 59(49.2) 66(55.0) 75(62.5) 62(51.7) 63(52.5) 58(48.3) 57(47.5) 55(45.8)
Aware of the incidence of *Salmonella*.	Yes	75(62.5)	74(61.7)
Aware of the incidence of *Salmonella* on someone's farm.	Yes	75(62.5)	75(62.5)
Age of chicks with *Salmonella*.	Below 6wks 6wks - 8wks 9wks - 11wks Above 11wks	19(15.8) 36(30.0) 15(12.5) 6(5.0)	20(16.7) 34(28.3) 15(12.5) 5(4.2)
Farm workers are aware of *Salmonella*.	Yes	66(55.0)	65(54.2)
Farm workers observe protocols against *Salmonella*.	Yes	47(39.2)	47(39.2)
Seasons experiencing the disease.	Dry season Rainy season Anytime	34(28.3) 63(52.5) 23(19.2)	33(27.5) 64(53.3) 23(19.2)
The disease is of serious economic importance.	Yes	26(21.7)	25(20.8)
The farm has a policy of restricted person's access.	Yes	52(43.3)	52(43.3)
Visitors are delayed for 48-72 hours between visits.	Yes	54(45.0)	54(45.0)
Vehicle wheel wash for visitors is maintained.	Yes	64(53.3)	64(53.3)
Footbaths filled with sanitiser are maintained.	Yes	89(74.2)	89(74.2)
Hand washing facilities are maintained.	Yes	81(67.5)	81(67.5)
Availability of ante-room facility before entry.	Yes	54(45.0)	54(45.0)
Workers and visitors wear personal protective equipment (PPE) before entry.	Yes	77(64.2)	77(64.2)
Workers and visitors change their clothes in between pen houses.	Yes	73(60.8)	73(60.8)
Wild animals and birds access poultry pens and feed.	Yes	66(55.0)	66(55.0)
Rodents have access to poultry pens.	Yes	60(50.0)	60(50.0)
Domestic pets have access to poultry.	Yes	77(64.2)	77(64.2)
Other livestock are kept on the poultry farm.	Yes	87(72.5)	72(60.0)
Dead birds are disposed of.	Yes	79(65.8)	74(61.7)
Staff/workers are trained for *Salmonella* control.	Yes	74(61.7)	88(73.3)

Source = Field Survey (2021)

Furthermore, all birds were reared across the sampled area, with the majority (74.2% and 71.7%) of the respondents in Osun and Ogun states involved in broiler production. Most (61.7% and 46.7%) of the respondents in Osun and Ogun states had heard of *Salmonella* infection, and 59.2% had experienced *Salmonella* outbreaks across the states. Most participants (64.2% and 62.5%) in Osun and Ogun states had tested incoming feed for *Salmonella*. In comparison, more than half (57.5% and 55.8%) of the respondents in Osun and Ogun states had tested water for *Salmonella*. Borehole was the primary water source in Osun state poultry farms, as indicated by 50.0% of the respondents, and 59.2% of the respondents in Ogun state sourced from healthy water. The majority (75.0% and 65.0%) of the birds in Osun and Ogun states were single-aged, as revealed by respondents. The study's findings further revealed that chicks were not tested free from *Salmonella* in Osun (61.7%), and most (90.8%) of the respondents affirmed that they had tested chicks free from *Salmonella* in Ogun state. Half (50.0%) of the respondents in Osun state carried out routine microbiological sample tests for *Salmonella*. In Ogun state, 62.5% did not conduct routine microbiological sample tests for *Salmonella*. Also, 52.5% of respondents did not conduct routine microbiological sample verification tests between flocks in Osun state, and 50.8% affirmed that they had carried out routine microbiological sample verification tests between flocks in Ogun state. Suppose farm management practices can be properly harnessed. In that case, Nigeria's poultry industry holds significant potential to improve food and nutritional security while also contributing to household income and broader economic growth (Heise, 2015). Although several studies have reported *Salmonella* infections in commercial poultry flocks (Muhammad *et al.*, 2010; Agbaje *et al.*, 2010; Fagbamila *et al.*, 2017; Mshelbwala *et al.*, 2017; Jibril *et al.*, 2020), the *Salmonella* status of indigenous poultry remains largely under explored.

Table 3. Information on general farm management (n =240).

Variables	Response	Osun State (%)	Ogun State (%)
Type of production system on the poultry farm.	Intensive Semi-intensive Others	24(20.0) 88(73.3) 8(6.7)	64(53.3) 56(46.7) 0(0)
Type of birds on the farm.	Layers Breeders Broilers	88(73.3) 83(69.2) 88(73.3)	74(61.7) 70(58.3) 74(61.7)
Farm record of disease outbreaks is kept.	Yes Sometimes	60(50.0) 45(37.5)	67(55.8) 10(8.3)
Visitors' records are kept.	Yes Sometimes	66(55.0) 42(35.0)	51(42.5) 8(6.7)
Other animals are kept near birds.	Yes Sometimes	53(44.2) 58(48.3)	74(61.7) 0(0)
Type of labour used on the farm.	Family labour Hired labour Self labour	74(61.7) 98(81.7) 85(70.8)	76(63.3) 72(60.0) 90(75.0)
Type of rearing style.	Deep litters Cage systems Both	22(18.3) 37(30.8) 61(50.8)	24(20.0) 42(35.0) 54(45.0)
Types of poultry birds reared.	Broiler's production Layers production Breeders' production Cockerels' production	89(74.2) 76(63.3) 71(59.2) 59(49.2)	78(65.0) 71(59.2) 57(47.5) 86(71.7)
I heard of *Salmonella* infection.	Yes Sometimes	74(61.7) 32(26.7)	32(26.7) 56(46.7)
Experienced *Salmonella* outbreak.	Yes Sometimes	71(59.2) 35(29.2)	71(59.2) 13(10.8)
Incoming feed for *Salmonella* is tested.	Yes Sometimes	77(64.2) 29(24.2)	75(62.5) 16(13.3)
Water for *Salmonella* is tested.	Facial looking Laboratory test Litmus test	69(57.5) 43(35.8) 8(6.7)	67(55.8) 45(37.5) 8(6.7)
Source of water.	Well Borehole Stream	54(45.0) 60(50.0) 6(5.0)	71(59.2) 41(34.2) 8(6.7)
Are birds single or multi-aged?	Single-aged Multi-aged	90(75.0) 30(25.0)	78(65.0) 42(35.0)
Source of bird replacement.	Single Multiple Both	110(91.7) 2(1.7) 8(6.7)	70(58.3) 29(24.2) 21(17.5)
Chicks are tested free from *Salmonella*.	Yes	46(38.3)	109(90.8)
Routine microbiological sample tests for *Salmonella*.	Yes	60(50.0)	45(37.5)
Routine microbiological sample verification tests between flocks.	Yes	57(47.5)	61(50.8)

Source = Field Survey (2021)

Extension advisory service to poultry farmers

Results in Table 4 showed most (50.0%) respondents in Osun state had 11 – 15 years of experience in extension services, and 46.6% in Ogun state had 15 – 20 years of experience in extension services. On how often extension workers visited poultry farmers, as indicated by most respondents, 40.0% and 36.7% in Osun occasionally and often and 38.3% and 31.7% frequently and always in Ogun state visited poultry farmers, respectively. The majority (83.3% and 91.7%) of respondents in Osun and Ogun states were very knowledgeable about poultry diseases, especially *Salmonella* infections. Across the states, information about precautionary measures for *Salmonella* diseases was disseminated to poultry farmers, as indicated by most respondents in Osun (66.7%) and Ogun (78.3%). On some of the precautional measures relay to poultry farmers in the study area, findings show that in Osun state, most of the workers disseminate information on adequate frying of poultry meat after boiling before eating (81.7%), vaccination of poultry birds as at when due (75.0%), washing and cleaning of hands and fingernails at all times (71.6%), burying of dead poultry birds (70.0%) adequate cooking of poultry meat before eating (63,3%) and so on while in Ogun state, finding reveals that vaccination of poultry birds as at when due (83.3%), adequate frying of poultry meat after boiling before eating (80.0%), washing of poultry eggs before boiling (75.0%), burying of dead poultry birds (73.3%), regular washing of hands before putting food items into mouth (71.7%) and so on.

The result shows that the majority (70.0%) of respondents in Ogun state and above half, 34 (56.7%) of them in Osun state, revealed that poultry farmers had never complained about poultry diseases, especially *Salmonella* infectious diseases in the study location. Efficient extension service delivery is critical for driving agricultural development in developing countries (Ashley-Dejo, 2012). The effectiveness of extension agents can often be assessed by the relevance and volume of useful information they disseminate, which directly influences farmers' ability to enhance productivity (Ashraf *et al.*, 2018).

Table 4. Extension advisory service to poultry farmers (n = 60).

Extension advisory services	Osun (%)	Ogun (%)
Years of experience in extension service		
≤ 10 years	8(13.3)	10(16.7)
11 – 15	30(50.0)	12(20.0)
15 – 20	10(16.7)	28(46.6)
Above 20 years	12(20.0)	10(16.7)
How often did you visit poultry farmers in your location?		
Always	12(20.0)	19(31.7
Often	22(36.7)	23(38.3)
Occasionally	24(40.0)	13(21.7)
Never	2(3.3)	5(8.3)
Are you very knowledgeable about poultry diseases, especially Salmonella, which are infectious?		
Yes	50(83.3)	55(91.7)
Did you disseminate information about precautional measures for Salmonella diseases to poultry farmers?		
Yes	40(66.7)	47(78.3)
Kindly identify some of the precautional measures relay to poultry farmers against Salmonella.		
Regular washing of hands before putting food items into mouth	30(50.0)	43(71.7)
Vaccination of poultry birds as when due	45(75.0)	50(83.3)
Proper fumigation of poultry houses and birds against disease	35(58.3)	38(63.3)
Adequate cooking of poultry meat before eating	38(63.3)	39(65.0)
Washing of poultry eggs before boiling	37(61.7)	45(75.0)
Adequate frying of poultry meat before consumption	49(81.7)	48(80.0)
Washing and cleaning of fingernails at all times	43(71.6)	36(60.0)
Bury of dead poultry birds	42(70.0)	44(73.3)
How often did poultry farmers complain about poultry diseases in your location, especially infectious Salmonella?		
Always	8(13.3)	4(6.7)
Often	8(13.3)	9(15.0)
Occasionally	10(16.7)	5(8.3)
Never	34(56.7)	42(70.0)

Source = Field Survey (2021)

Poultry farmers disposition to extension advisory service

Table 5 shows information about poultry farmers' disposition to extension advisory services in Osun and Ogun states. Most respondents (i.e., poultry farmers) (56.7% and 70.0%) in Osun and Ogun states had over 15 years of experience enjoying extension services, respectively. On how often extension workers visited poultry farmers, the results indicated that most respondents, 40.0% and 36.7% in Osun occasionally and frequently, while 38.3% and 26.7% often and always in Ogun state indicated extension visits to the farmers, respectively. Most (75.0% and 87.5%) of the Osun and Ogun state respondents agreed that extension workers were knowledgeable about poultry diseases, especially *Salmonella* infection in the two states. Across the states, information about precautionary measures for *Salmonella* diseases was disseminated to poultry farmers as indicated by most respondents, 62.5% in Osun and 68.3% in Ogun state. On some of the precautional measures extension workers disseminate to poultry farmers in the study area, findings show that in Osun state, respondents agreed that adequate frying of poultry meat after boiling before eating (82.5%), vaccination of poultry birds as when due (75.0%), washing and cleaning of hands and fingernails at all times (73.3%), burying of dead poultry birds (70.8%), adequate cooking of poultry meat before eating (65,0%) and so on while in Ogun state, finding reveals that vaccination of poultry birds as at when due (91.7%), adequate frying of poultry meat after boiling before eating (83.3%), washing of poultry eggs before boiling (76.7%), bury of dead poultry birds (74.2%), regular washing of hands before putting food items into the mouth (72.5%) and so on.

Furthermore, the result shows that most (61.7%) of respondents in Ogun state and half (50.0%) in Osun state revealed that poultry farmers had never complained about poultry diseases, especially *Salmonella* infectious diseases, to extension workers in the study location. In comparison, a few (23.3%) occasionally and (16.7%) in Ogun state often complained to extension workers in the study locations. Disposition in this study refers to farmers' opinions about the extension training programme, the distribution channels, the kind of technology, and the field visits that farmers receive. Cheerful disposition encourages the acceptance of technologies, while a negative attitude hampers the acceptance of technologies. Extension and advisory services hold excellent prospects in this regard. Worldwide, agricultural extension and advisory services (AEAS) help promote agricultural innovations and development through skills dissemination and problem-solving for improved livelihoods (Sebuliba-Mutumba *et al.*, 2017). The procedure by which an individual or a group of persons interprets information from their surroundings into psychological awareness is known as perception (Forbang *et al.*, 2019).

Table 5. Poultry Farmers Disposition to Extension Advisory Service.

Poultry farmers disposition	Osun (%)	Ogun (%)
How long have you been enjoying extension service in your location		
≤ 10 years	16(13.3)	8(6.7)
11 – 15	36(30.0)	28(23.3)
Above 15 years	68(56.7)	84(70.0)
How often did extension workers visit your poultry farmers?		
Always	20(16.7)	32(26.7)
Often	44(36.7)	46(38.3)
Occasionally	48(40.0)	28(23.3)
Never	8(6.7)	14(11.7)
Are extension workers knowledgeable about poultry diseases, especially *Salmonella* infectious?		
Yes	90(75.0)	105(87.5)
Did the extension worker disseminate information about precautional measures for poultry diseases (esp. *Salmonella* diseases)		
Yes	75(62.5)	82(68.3)
Did you take some of the precautional measures disseminated to you about poultry diseases (esp. *Salmonella* diseases)		
Regular washing of hands before putting food items into mouth	65(54.2)	87(72.5)
Vaccination of poultry birds as when due	90(75.0)	110(91.7)
Proper fumigation of poultry houses and birds against disease	70(58.3)	78(65.0)
Adequate cooking of poultry meat before eating	78(65.0)	82(68.3)
Washing of poultry eggs before boiling	75(62.5)	92(76.7)
Adequate frying of poultry meat before consumption	99(82.5)	100(83.3)
Washing and cleaning of fingernails at all times	88(73.3)	76(63.3)
Bury of a dead bird	85(70.8)	89(74.2)
How often did you complain about poultry diseases, esp. *Salmonella* infectious diseases to extension workers?		
Always	10(8.3)	8(6.7)
Often	22(18.3)	18(15.0)
Occasionally	28(23.3)	20(16.7)
Never	60(50.0)	74(61.7)

Source = Field Survey (2021)

Conclusions

This study concluded that most of the respondents sampled were young, agile, experienced and vibrant able men who are ready for innovation in poultry production. There is a high level of awareness among the respondents (i.e., poultry farmers), the majority of the respondents were aware of the incidence, season of experience and probable age of incidence among chicks. Knowledge level about the *Salmonella* outbreak is somewhat higher based on the respondent's response. Agricultural extension and advisory services facilitate farmers' access to new knowledge, information and technologies. The notable major sources of information about *Salmonella* diseases were extension worker, family and friends, and ADP in the two states. Well and borehole serves as a major source of water, and the facial look and laboratory test for water were considered for *Salmonella* testing in the study area. Generally, the agricultural extension systems in Nigeria were challenged by a limited number of well-trained extension agents, limited staff, inadequate funding, lack of visitation and many more factors, which have had low adverse effects on the growth and development of the agricultural sectors, especially livestock farming. It was recommended, among others that government and Non-Governmental Organisations (NGOs) extension agents, with other agricultural development stakeholders, should endeavor to train, educate and empower more youth and agile poultry farmers through adequate innovations and enforcement of biosecurity that will stimulate their interest in poultry production in the study areas.

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