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# Prevalence and Risk Factors for Multidrug-Resistant *Salmonella* in Poultry Houses in Parts of Nasarawa Town, Nasarawa State, Nigeria

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## Abstract

*Salmonella is a significant zoonotic bacterium with implications for public health. This study investigated the prevalence and associated risk factors for Salmonella in poultry houses located in Nasarawa town, Nasarawa State, Nigeria. A total of sixty samples, including hand swabs from poultry handlers, surface swabs from the poultry pen, egg shells, feed, and faecal droppings, were analyzed for the presence of multidrug-resistant Salmonella using standard microbiological techniques. A structured questionnaire was administered to identify risk factors linked to the occurrence of Salmonella in these poultry houses. Chi-square statistical analysis was performed to evaluate the relationship between the identified risk factors and the occurrence of multidrug-resistant Salmonella. The overall prevalence of Salmonella was found to be 21.7% (13 out of 60 samples). A significant statistical relationship (p = 0.031) was determined between the occurrence of Salmonella and the various sample types analysed. Additionally, a statistically significant association (p= 0.014) was observed between the presence of rodents in the pens, lack of footbath disinfection, source of drinking water, and the presence of other livestock, with the occurrence of Salmonella in the poultry houses. All 13 Salmonella isolates displayed complete (100%) resistance to ampicillin, augmentin, and chloramphenicol. This research provides foundational data on the risk factors contributing to the prevalence of multidrug-resistant Salmonella in poultry houses within parts of Nasarawa, Nigeria. The alarming level of antibiotic resistance seen in the Salmonella isolates poses a significant public health threat.*

**Keywords:** Multidrug resistance, poultry, public health, risk factors, *Salmonella*.

## INTRODUCTION

*Salmonella* is a significant zoonotic bacterial pathogen responsible for foodborne infections worldwide (Ferrari *et al.*, 2019). The presence of such pathogenic bacteria in livestock, including food animals, presents a major public health challenge on a global scale. Poultry, being one of the most widely consumed meat products in both developed and developing nations, can act as a reservoir for *Salmonella*. In Africa, specifically Nigeria, about 80% of chickens are local breeds, with approximately 60% reared in backyard systems. These systems

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often involve inexperienced farmers, which can exacerbate the incidence and dispersion of antimicrobial resistance (AMR) (Mpenda *et al.*, 2019; Oloso *et al.,* 2019; Moffo *et al.,* 2020). In contrast, larger commercial poultry farms predominantly use intensive farming methods, such as deep litter systems for broilers and battery cages for layers. These production systems frequently incorporate antimicrobials to sustain flock health and enhance productivity (Alhaji *et al.,* 2018). However, the routine use of antimicrobials for prophylactic, metaphylactic, and growth promotion purposes contributes to the rise and spread of antibiotic-resistant strains, including *Salmonella* (Adesiyun *et al.*, 2020).

The poultry industry plays a vital role in Nigeria's economy, fostering national growth and creating numerous job opportunities (Odine *et al.,* 2015). Poultry farming not only serves as a livelihood for many families but also contributes significantly to the local meat production, accounting for approximately a quarter of the total output, thereby enhancing per capita consumption of animal protein among the populace (Adebayo and Adeola, 2005). Despite these benefits, small-scale poultry farmers in Nigeria face substantial losses, with reports indicating that up to 18% of chicks may perish during the critical first two weeks of life, often as a result of *Salmonella* infections. This mortality significantly impacts food security and the economic wellbeing of these farmers (Agbaje *et al.,* 2010).

Salmonellosis in birds has emerged as a significant public health concern in Nigeria, resulting in substantial economic losses and increased morbidity and mortality rates in both humans and animals (Muhammed *et al.,* 2010; Fagbamila *et al.,* 2017). Several serovars of Salmonella found in poultry are also prevalent in humans (Orum *et al.*, 2022), indicating a potential epidemiological link between infections in humans and poultry, thus facilitating the spread of the pathogen. *Salmonella* can contaminate poultry and is disseminated widely among breeding flocks at all stages of the production process, including hatching, slaughtering, processing, transportation, and retail, ultimately leading to human exposure (Jibril *et al.,* 2015). The resistance of bacterial pathogens to antimicrobials represents a global challenge, leading to diminished efficacy of treatment options for both human and animal infections, as well as increased morbidity and mortality (Foley *et al.,* 2008). The rise of multiple antibiotic-resistant bacteria poses an escalating threat to human and livestock health worldwide, including in Nigeria. The extensive use of antimicrobials in poultry farming has been associated with heightened levels of antimicrobial resistance among bacterial pathogens, including Salmonella, found in poultry and their environments (Liselotte *et al.,* 2010). Consequently, poultry operations may serve as reservoirs for multidrug-resistant pathogens, which have the potential to be transmitted to humans through direct contact or consumption of poultry products and food grown in soil enriched with poultry manure. This study aims to evaluate the prevalence and risk factors linked to multidrug-resistant *Salmonella* in poultry houses located in parts of Nasarawa town, Nasarawa State, Nigeria.

## MATERIALS AND METHODS

### Study Area

The study was conducted in Nasarawa town, located in Nasarawa State, Nigeria. The area encompasses a land mass of approximately 5,704 square kilometers and has an estimated population of over 217,520 as reported in 2011. Nasarawa Local Government Area (LGA) ranks as the third most populated LGA within the state. The state itself is bordered to the north by Kaduna State, to the west by Abuja (Federal Capital Territory), to the south by Kogi and Benue States, and to the east by Taraba and Plateau States (Abdulkarim *et al.,* 2016).

**Sample Size**

The sample size was determined based on a reported prevalence of 3.5% of Salmonella in poultry by Babatunde *et al.* (2017). The formula used for the calculation was adapted from Naing *et al.* (2006):

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

Where n = sample size; P = prevalence from a previous study = 3.5% = 0.035; Z = standard normal distribution at 95% confidence interval = 1.96, d = absolute desired precision at 5% = 0.05.

Therefore, $n = \frac{Z^2 P (1-P)}{d^2}$

Where n is the sample size;
P is the prevalence from a previous study = 3.5% = 0.035;
Z is the standard normal distribution at 95% confidence interval = 1.96;
d is the absolute desired precision at 5% = 0.05.

**Collection of Samples**

Sixty (60) samples, including hand swabs from poultry handlers, surface swabs from pens, egg shells, poultry feed, and faecal droppings, were collected from various poultry farms within Nasarawa town between March 2024 and May 2024. Faecal samples and poultry feed were aseptically collected in clean sterile containers, while swabs were taken using sterile swab sticks moistened with sterile peptone water. Prior to sample collection, voluntary and informed consent was obtained from poultry owners and farm handlers. Ethical approval for the study was also secured. Sterile plastic bags were used to collect poultry droppings and feeds, while swabs from farm handlers and egg surfaces were transferred into buffered peptone water (BPW) (Oxoid, UK). The samples were immediately transported to the Microbiology Laboratory of the Department of Applied Biology/Microbiology, Federal Polytechnic, Nasarawa, in a cooler packed with ice blocks.

**Sample Processing**

Twenty-five grams of each poultry dropping sample were pre-enriched in 225 ml of buffered peptone water (BPW) and incubated at 37$^{o}$C for 24 hours. A loopful of culture from the enriched broth was then streaked onto prepared plates of *Salmonella-Shigella* agar (Oxoid, UK) and Deoxycholate Citrate Agar (DCA). The cultured plates were incubated at 37$^{o}$C for 24 to 48 hours (OIE, 2012).

Twenty-five grammes (25g) of representative poultry feed samples were also pre-enriched in 225 ml of BPW and incubated at 37$^{o}$C for 24 hours. One millilitre of each enriched culture was transferred into 9 ml of Rappaport-Vasiliadis Broth (RVB) (Oxoid, UK), followed by incubation at 37$^{o}$C for 24 hours. A loopful of culture from the RVB was then sub-cultured onto SSA and DCA plates, which were incubated at 37$^{o}$C for 24 hours (Cardinale *et al.*, 2004).

Swab samples from the hands of poultry farm handlers were collected using sterile swab sticks moistened in normal saline. The swabs were cut with a sterile scalpel blade and placed into 10 ml of BPW in screw-capped bottles for an incubation period of 37$^{o}$C for 24 hours for pre-enrichment. One millilitre of this pre-enriched broth was then transferred into tubes containing 9 ml of RVB for further incubation at 37$^{o}$C for 24 hours. A loopful of culture from

the RVB was sub-cultured onto SSA and DCA plates, incubated at 37°C for an additional 24 to 48 hours (OIE, 2012).

Swabs from egg shells were similarly collected, cut into 10 ml of BPW in screw-capped bottles, and incubated at 37°C for 24 hours for pre-enrichment. The process followed was consistent with that used for hand swabs, involving transfer to RVB and subsequent sub-culture onto SSA and DCA plates for incubation (Suresh *et al.*, 2006; OIE, 2012).

**Isolation and Identification of *Salmonella***

The incubated plates were examined for the presence of typical *Salmonella* colonies, characterised by transparent colonies with black centers on SSA and pale or colorless colonies, with or without black centers on DCA. The isolates were sub-cultured onto freshly prepared SSA plates and nutrient agar for the isolation of pure cultures and subsequent biochemical characterisation (Cheesbrough, 2010).

**Identification and Biochemical characterisation of the *Salmonella* isolates**

Gram's staining procedures were carried out on positive colonies obtained from positive plate above as follows: a thin smear of a colony was made with a drop of sterile distilled water on previously clean glass slide and allowed to air dry. The smear was then fixed by passing the slide over a gentle Bunsen flame 3 times. The fixed smear was then be flooded with crystal violet dye and allowed to stand for 1 minute. Thereafter, the dye was rinsed off with a slow running tap water. Gram's iodine was then added to cover the smear for another one minute and then rinsed with slow running tap water. The smear was thereafter decolourised with acetone for 8-10 seconds. The smear was counter stained with safranin and allowed to stand for 30 seconds. before rinsing with slow running tap water. The stained smear was allowed to air dry and then observed with the oil immersion objective. Reddish-pink rods were presumed to be *Salmonella* (Cheesbrough, 2010).

**Procedures for selected biochemical tests**

***Triple sugar iron agar (TSI) test***

One of the well-isolated colonies was selected from a *Salmonella* cultured plate using a sterile wire loop. The centre of the colony was touched and a prepared TSI medium was inoculated by stabbing the butt and streaking the slants. This was then incubated at 37°C for 24 hours. A yellow butt (acid) and red or pink (alkaline) slope indicated the fermentation of glucose only. Cracks and bubbles in the medium indicated gas production from glucose fermentation. A yellow (acid) butt indicated the fermentation of lactose. A red or pink (alkaline) slope and butt indicated no fermentation of glucose or lactose. Blackening along the slant line or throughout the streaked indicated hydrogen sulphide ($H_2S$) production. *Salmonella* forms a red slope (alkaline) and yellow (acid) butt with/out gas or $H_2S$ production (Cheesbrough, 2010).

***Urease test***

With the aid of a straight inoculating wire, *Salmonella* –like colonies were picked and a urea agar was inoculated heavily over the entire surfaces of urea agar slants in Bijou bottles. The caps were loosened and then incubated at 37°C for 3-12 hours. A urease-positive culture produced an alkaline reaction in the medium, evidenced by pinkish-red colour of the medium. Urease-negative organisms do not change the colour of the medium, which is pale yellow-pink. *Salmonella* is always urease-negative (Cheesbrough, 2010).

***Citrate utilisation test***

Simmon's citrate agar slants were prepared in Bijou bottles in accordance with the

manufacturer's instructions. Colonies obtained from incubated plates were inoculated into the slants and incubated at 37$^{o}$C for 24-48 hours with the Bijou bottles loosely capped. The development of a deep blue colour indicated positive results. The principle behind this test is based on the fact that, Simmon's citrate agar medium contains the pH indicator bromothymol blue and sodium citrate as the sole carbon source. Only organisms capable of metabolising citrate would grow on this medium since the medium has no other carbon source that can be utilised for growth (Cheesbrough, 2010).

***Motility test***

*M*otility agar was prepared according to manufacturer's instructions and inoculated with *Salmonella*-like colonies using a sterile inoculating needle, making a stab of about 1-2 cm down into the medium. Motility was examined after 37$^{0}$C for 24 hours. Motility was indicated by the presence of diffused growth (appearing as colouring of the medium) away from the line of inoculation. With the exception of *Salmonella* Pullorum-Gallinarum, all *Salmonella* species are motile (Cheesbrough, 2010).

**Antibiogram of the *Salmonella* Isolates**

***Preparation of 0.5 McFarland turbidity standard***

The 0.5 McFarland turbidity standard was prepared by combining 0.6 ml of 1% barium chloride dihydride with 100 ml of 1% sulfuric acid in a graduated cylinder. This standard solution was then transferred into a small tube and stored in the dark at room temperature, where it could remain stable for up to six (6) days, provided it was sealed to prevent evaporation (Cheesbrough, 2010).

***Determination of antibiotic susceptibility of the Salmonella isolates***

An inoculum of the test organism (*Salmonella*) was made from the primary culture plate by selecting three pure colonies using a sterile wire loop. These colonies were transferred into a small tube containing normal saline. The turbidity of the test organism was compared to that of the McFarland standard. The density of the suspension was adjusted to match that of the McFarland standard by adding additional bacterial colonies or more sterile normal saline. Proper turbidity adjustment was crucial to achieve uniform growth on the Petri dish. Next, Mueller-Hinton agar plates were inoculated by dipping a sterile swab stick into the tube containing the test organism suspension. The swab stick was used to evenly coat the surface of the medium, extending to the edges of the dish. The inoculated plates were allowed to dry for a few minutes at room temperature with the lids closed before antibiotic discs were applied. Up to five (5) antibiotic discs were placed on each plate: four discs were positioned approximately 15 mm from the edge, and one was centered on the plate. Each disc was pressed gently to ensure adequate contact with the agar medium. The plates were incubated at 37$^{o}$C for 18 to 24 hours within 30 minutes of the preparation. After incubation, the diameter of the zone of inhibition around each disc was measured and recorded in millimeters using a meter rule on the underside of the plate without opening the lid. Measurements were interpreted based on guidelines provided by the Clinical and Laboratory Standard Institute (CLSI, 2016). The antibiotics evaluated in this study included streptomycin, ofloxacin, pefloxacin, gentamicin, augmentin, ciprofloxacin, amoxicillin, sparfloxacin, chloramphenicol, and co-trimoxazole.

**Assessment of Risk Factors Associated with the Occurrence of *Salmonella* in Poultry Houses**

A closed-ended structured questionnaire was employed to assess the risk factors associated with the occurrence of *Salmonella* in poultry houses in various locations of Nasarawa town.

Informed consent was obtained from the farmers to facilitate the accurate completion of the questionnaire as part of the study.

**Statistical Analysis**

Data collected during the study were entered into Microsoft Excel for subsequent statistical analysis. All percentages were presented alongside their absolute values. The results were organised and displayed in table and figure formats for clarity and ease of interpretation.

## RESULTS AND DISCUSSION

Out of the 60 samples examined, 13 were found to be contaminated with *Salmonella*, resulting in an overall prevalence rate of 21.7%. The results of the biochemical identification of the *Salmonella* isolates are presented in Table 1. The breakdown of *Salmonella* contamination by location is as follows: In Nasarawa Market, out of the 20 (25%) samples collected, 5 tested positive for *Salmonella*. Out of the 20 samples obtained from Gunki and Shagari Road each, 4 (20%) were positive for *Salmonella* respectively (Table 2). The occurrence of 21.7% of *Salmonella* as recorded in this study aligns closely with the findings of Orum *et al.* (2022), who reported a 21.4% occurrence in poultry from Ibadan, Oyo State, Nigeria. This similarity underscores a consistent level of occurrence of *Salmonella* in poultry across the different parts of Nigeria. Jibril *et al.* (2020) documented a lower prevalence of 15.9% in commercial poultry farms nationally, while Ibrahim *et al.* (2019) reported a prevalence of 13.7% specifically in Nasarawa State. Ban-bo *et al*. (2023) reported an even lower rate of 6.74% in poultry farms in Ibadan, suggesting that prevalence of *Salmonella* varies significantly in relation to location and farm conditions. The impact of geographical differences cannot be overstated. Factors such as climate, local farming practices, and regional biosecurity measures contribute to differing prevalence rates. Studies by Jibril *et al.* (2020) and Ibrahim *et al.* (2019) have shown how geographic factors can affect *Salmonella* occurrence, likely due to variations in environmental exposure and management practices in poultry houses. Effective biosecurity measures, including vaccination protocols and overall hygiene standards, are critical in controlling *Salmonella* in poultry. Poor hygiene and biosecurity practices often correlate with higher *Salmonella* rates, as highlighted by Ammar *et al.* (2016), Langata *et al.* (2019), and Raufu *et al.* (2019). The findings from this study revealed that the majority of *Salmonella* isolates occurred in faecal droppings, identifying this 'material' as a significant reservoir of the pathogen. Although the *Salmonella* could have emanated from the birds due to infection as a result of lack of or inappropriate vaccination, it is also possible that the environment in and around the pens were contaminated with *Salmonella* that have been carried by human footwears into the vicinity of the pens. A statistically significant association ($p$ = 0.014) between movement from one pen to another and the occurrence of *Salmonella* in the poultry houses. These findings not only highlight the critical control points for *Salmonella* in poultry farms, but also underscores the importance of rigorous sanitation practices. Enhancing hygiene protocols, particularly with regards to faecal management and cleaning of interactions surfaces, along with proper handwashing practices for handlers, is essential for mitigating the spread of *Salmonella* in poultry production.

**Table 1: Biochemical Characterisation and Identication of *Salmonella* in Poultry Houses in Parts of Nasarawa Town**

| Isolates | GR | MOT | MR | IN | Identified bacterium |
|---|---|---|---|---|---|
| $PF_1$ | – | + | + | – | *Salmonella* species |
| $PF_2$ | – | + | + | – | *Salmonella* species |
| $PD_1$ | – | + | + | – | *Salmonella* species |
| $PD_2$ | – | + | + | – | *Salmonella* species |
| $PD_3$ | – | + | + | – | *Salmonella* species |
| $HS_1$ | – | + | + | – | *Salmonella* species |
| $HS_2$ | – | + | + | – | *Salmonella* species |
| $PS_1$ | – | + | + | – | *Salmonella* species |
| $PS_2$ | – | + | + | – | *Salmonella* species |
| $HS_3$ | – | + | + | – | *Salmonella* species |
| $ES_1$ | – | + | + | – | *Salmonella* species |
| $HS_4$ | – | + | + | – | *Salmonella* species |
| $ES_2$ | – | + | + | – | *Salmonella* species |

Key: (+) = Positive; (–) = Negative; (GR) = Gram reaction; (MOT) = Motility; (MR) = Methyl Red; (IN) = Indole.

**Table 2: Occurrence of *Salmonella* in Poultry Houses in Parts of Nasarawa Town**

| Sampling area | | No. Examined | No. Positive | (%) Occurrence | $X^2$ |
|---|---|---|---|---|---|
| **Market** | | | | | |
| | Poultry feed | 4 | 0 | 0 | |
| | Poultry droppings | 4 | 3 | 75 | |
| | Swab from poultry handlers | 4 | 1 | 25 | 0.092 |
| | Surface of pen | 4 | 1 | 25 | |
| | Egg shell | 4 | 0 | 0 | |
| **Gunki** | | | | | |
| | Poultry feed | 4 | 0 | 0 | |
| | Poultry droppings | 4 | 2 | 50 | |
| | Swab from poultry handlers | 4 | 1 | 25 | 0.358 |
| | Surface of pen | 4 | 1 | 25 | |
| | Egg shell | 4 | 0 | 0 | |
| **Shagari Road** | | | | | |
| | Poultry feed | 4 | 0 | 0 | |
| | Poultry droppings | 4 | 3 | 75 | |
| | Swab from poultry handlers | 4 | 0 | 0 | |
| | Surface of pen | 4 | 1 | 25 | 0.031* |
| | Egg shell | 4 | 0 | 0 | |
| **Total** | | 60 | 13 | 21.7 | |

No. = Number

The results of the antibiotic susceptibility profile of the *Salmonella* isolates from poultry houses in Nasarawa are presented in Table 3. The isolates showed complete resistance (100%) to ampicillin, augmentin and chloramphenicol. The very high resistance of *Salmonella* isolates to ampicillin and augmentin as recorded in this study is similar to the 92.3 and 97.8% recorded for ampicillin and augmentin respectively by Ibrahim *et al*. (2019) in a study conducted to determine the antibiotic resistance of *Salmonella* from commercial poultry and poultry handlers in Keffi, Nasarawa State, Nigeria. This is could be reflection of an extensive use of β-lactam antibiotics in the study area. The continuous use and misuse of antibiotics in an area promotes resistance in bacteria due to selective pressure. This finding is not baffling because

outside the hospital environment, people can access antibiotics at any drugstore easily without a prescription from qualified personnel. The resistance to the above-mentioned antibiotics could also be a reflection of cross-contamination of the poultry houses with β-lactam resistant *Salmonella* strains derived from human sources. *Salmonella* strains that are resistant to one β-lactam antibiotic can easily develop resistance to the others because they exhibit the same basic structure and have the same mechanism of activity (Suleiman *et al.*, 2012). This study also recorded a very high resistance (92.3%) of *Salmonella* isolates to co-trimoxazole. This agrees with the report of Obi and Ike (2015) who recorded 100% resistance of *Salmonella* obtained from poultry to the antibiotic in Nsukka, Nigeria. It is also similar to the reports of Orum *et al.* (2022) who recorded high levels of co-trimoxazole resistant *Salmonella* strains from poultry in Ibadan, Nigeria. This finding is surprising because co-trimoxazole is not antibiotics that is routinely used in poultry management in Nigeria. The co-trimoxazole resistant *Salmonella* strains obtained in this study could have found themselves in the poultry houses from human sources; perhaps from the poultry handlers, vehicular movement around the poultry houses, and/or from the water given to the birds. The relatively low resistance (30.7%) recorded for ciprofloxacin is similar to the findings of Yhiler *et al.* (2019) who reported 46.2% resistance of *Salmonella* obtained from poultry to the antibiotic in Calabar, Nigeria. This low resistance could be attributed to the fact that ciprofloxacin is not among the antibiotics that are routinely used in poultry management in Nigeria. Perhaps the ciprofloxacin-resistant strains obtained in this study could have been derived from human sources. Perhaps they have been carried into the poultry houses by the handlers or rodents. A higher level of resistance (63.7%) of *Salmonella* obtained from poultry has been reported by Ibrahim *et al.* (2019) from Keffi, Nigeria. The high level of resistance (92.3%) resistant of the isolates to streptomycin is similar to the report of Umeh and Enwuru (2014) who recorded 71% resistance of *Salmonella* isolated from poultry houses to the antibiotic in Owerri, Nigeria. This is quite confusing because streptomycin is an antibiotic that is used by poultry farmers either for prophylaxis or therapy which could have led to antibiotic resistance in bacteria as a result of selective pressure. Perhaps the streptomycin-resistant Salmonella obtained in this study originated from human sources.

Several factors contribute to the emergence and persistence of antibiotic-resistant *Salmonella*. Poor biosecurity measures and unhygienic practices within poultry operations can exacerbate the spread of resistant bacteria. Additionally, environmental contamination and limited access to veterinary services may hinder effective management of antibiotic use, further facilitating the rise and spread of these pathogens.

**Table 3: Antibiotic Susceptibility Profile of *Salmonella* in Poultry Houses in Parts of Nasarawa Town**

| | | n = 13 | | |
|---|---|---|---|---|
| Antibiotics | Disc conc. (µg) | S (%) | I (%) | R (%) |
| Streptomycin | 30 | 1 (7.6) | 0 (0.0) | 12 (92.3) |
| Ofloxacin | 10 | 2 (15.3) | 2 (15.3) | 9 (69.2) |
| Pefloxacin | 30 | 2 (15.3) | 0 (0.0) | 11 (84.6) |
| Gentamicin | 30 | 7 (53.9) | 2 (15.4) | 4 (30.8) |
| Augmentin | 10 | 0 (0.0) | 0 (0.0) | 13 (100.0) |
| Ciprofloxacin | 30 | 9 (92.3) | 0 (0.0) | 4 (30.7) |
| Ampicillin | 30 | 0(0.0) | 0 (0.0) | 13 (100.0) |
| Sparfloxacin | 10 | 0 (0.0) | 1 (7.6) | 12 (92.3) |
| Chloramphenicol | 30 | 0 (0.0) | 0 (0.0) | 13 (100.0) |
| Co-trimoxazole | 30 | 1 (7.6) | 0 (0.0) | 12 (92.3) |

*n = number of isolates; S = Susceptible; I =Intermediate; R = Resistance

Table 4 presents the results of the assessment of the risk factors associated with the occurrence of *Salmonella* in poultry houses located in various parts of Nasarawa town. The findings highlight several practices that may contribute to the risk of *Salmonella* contamination in these poultry environments. 66.7% of poultry houses reported vaccinating their birds against *Salmonella*, suggesting that a majority of producers are taking preventative measures. 33.3% of the poultry houses indicated that they sometimes administered antibiotics to their birds, which may contribute to antibiotic resistance if not managed appropriately. 66.7% of the poultry houses were found to be storing feed within the pen. 33.3% reported storing feed in a separate store, indicating a significant number of operations may be exposing feed to potential contamination. This is the first report of a study on the risk factors associated with *Salmonella* infection in poultry farms in Nasarawa, Nasarawa State, Nigeria. No published data exist on the subject matter prior to this study. Therefore, the findings of this study are discussed, compared and contrasted with studies in other parts of the world. This study also found a statistically significant association ($p$ = 0.0143) was found between the presence of rodents in the poultry houses and the occurrence of *Salmonella* in them suggesting that rodents could an important vehicle for the transmission of *Salmonella* to poultry. This agrees with the findings of Agada et al. (2014) who found a statistically significant association between the presence of rodents in poultry pens and the occurrence of *Salmonella* in the pens. The statistically significant association ($p$ = 0.0143) found between the non-use of disinfection footbath and the occurrence of *Salmonella* in the poultry houses (Table 4). It is possible that the environment around the pens were contaminated with *Salmonella* which have been carried into the pens by the footwears of the poultry handlers since they were not using disinfection footbaths regularly at the time of this study. These animals roam about, scavenging for food; there is a possibility of them picking up *Salmonella* from other places and introducing them into the poultry houses. A number of factors including the poultry house environment, unsafe drinking water, old litter, other farm animals and pets around the pens, rodents, insects, farm handlers, equipment and transport vehicles have been suggested as source of *Salmonella* infections in poultry (Agada *et al.,* 2014). It was generally observed that most of poultry farm owners were not knowledgeable about salmonellosis. This could be attributed to their low level of education on livestock-related issues, which indicates a lack of awareness on how the disease in acquired and transmitted. This might have contributed to the relatively high prevalence rate recorded in this study. The lack of knowledge also increased the risk of exposure and transmission of *Salmonella* by the farm handlers to flocks as reported by several studies, especially with the recent increase in poultry farming business in the country, Nasarawa inclusive. In addition, source of drinking water was associated with the occurrence of *Salmonella* in the poultry houses ($p$ = 0.011) (Table 4). This is quite surprising as majority of poultry owners said their birds were drinking water obtained from boreholes which is considered a safe water supply. It could be possible that the environment surrounding the boreholes in where the water was obtained were unhygienic with the place littered with dirt and close to water-logged culverts. Poor sanitary habits predispose underground water to contamination. Caincross and Cliff (1987) have shown that soakage pits can extend their influence on ground water quality up to 10m or more either vertically or laterally. Poultry farms using untreated water as a source of drinking water for chickens are more likely to have cases of salmonellosis contamination compared to those that use treated water.

**Table 4: Assessment of the Risk Factors Associated with the Occurrence of *Salmonella* in Poultry Houses in Parts of Nasarawa Town**

| Risk factor | Frequency | Percent | No. Positive | Prevalence (%) | $X^2$ | P-value |
|---|---|---|---|---|---|---|
| **Movement from one pen to another** | | | | | | |
| Yes | 0 | 0.0 | 0 | 0.0 | | |
| No | 3 | 100.0 | 3 | 100.0 | 6.000 | 0.0143 |
| Total | 3 | 100.0 | 3 | 100.0 | 0 | |
| **Storage of feed** | | | | | | |
| Within pen | 2 | 66.7 | 2 | 66.7 | | |
| Separate store | 1 | 33.3 | 1 | 33.3 | 0.666 | 0.4142 |
| Total | 3 | 100.0 | 3 | 100.0 | 7 | |
| **Use of footbath disinfection when entering the poultry house** | | | | | | |
| Yes | 0 | 0.0 | 0 | 0.0 | | |
| No | 3 | 100.0 | 3 | 100.0 | 6.000 | 0.0143 |
| Total | 3 | 100.0 | 3 | 100.0 | 0 | |
| **Farm previously contaminated with *Salmonella*** | | | | | | |
| Yes | 1 | 33.3 | 1 | 33.3 | | |
| No | 2 | 66.7 | 2 | 66.7 | 0.666 | 0.4142 |
| Total | 3 | 100.0 | 3 | 100.0 | 7 | |
| **Presence of rodents** | | | | | | |
| Yes | 0 | 0.0 | 0 | 0.0 | | |
| No | 3 | 100.0 | 3 | 100.0 | 6.000 | 0.0143 |
| Total | 3 | 100.0 | 3 | 100.0 | 0 | |
| **Reuse of egg parking trays** | | | | | | |
| **Yes** | 2 1 | 75.0 | 2 | 75.0 | | |
| No | 1 | 25.0 | 1 | 25.0 | 0.666 | 0.4142 |
| Total | 3 | 100.0 | 3 | 100.0 | 7 | |
| **Source of water** | | | | | | |
| Borehole | 3 | 100.0 | 3 | 100.0 | | |
| Tap | 0 | 0.0 | 0 | 0.0 | | |
| Well | 0 | 0.0 | 0 | 0.0 | 9.000 | 0.0111 |
| Total | 3 | 100.0 | 3 | 100.0 | 0 | |
| **Presence of other farm animals** | | | | | | |
| **Yes** | 0 | 0.0 | 0 | 0.0 | | |
| No | 3 | 100.0 | 3 | 100.0 | 6.000 | 0.0143 |
| Total | 3 | 100.0 | 3 | 100.0 | 0 | |
| **Parking of trucks near the poultry house** | | | | | | |
| **Yes** | 2 | 66.7 | 2 | 66.7 | | |
| No | 1 | 33.3 | 1 | 33.3 | 0.666 | 0.4142 |
| **Flock size** | | | | | | |
| < 200 | 2 | 66.7 | 2 | 66.7 | | |
| 300 – 400 | 1 | 33.3 | 1 | 33.3 | | |
| 500 – 700 | 0 | 0.0 | 0 | 0.0 | | |
| > 700 | 0 | 0.0 | 0 | 0.0 | 4.888 | 0.1801 |
| Total | 3 | 100.0 | 3 | 100.0 | 9 | |

## CONCLUSION

This study recorded a 21.7% prevalence of multidrug-resistant *Salmonella* in poultry houses in Nasarawa. All *Salmonella* isolates exhibited complete (100%) resistance to ampicillin, augmentin, and chloramphenicol. This poses a significant public health risk, as these multidrug-resistant *Salmonella* strains can be transmitted to humans through the food chain, leading to infections that are challenging to treat. The research identified several risk factors associated with the occurrence of *Salmonella* in the poultry houses, including the movement

of individuals between pens, the lack of footbaths, the presence of rodents in the pens, and the presence of other farm animals nearby. It is recommended that strict biosecurity measures be adopted, including routine and thorough cleaning, the implementation of disinfection protocols, and pest control programs within poultry houses. These measures will be essential in preventing *Salmonella* contamination. Furthermore, relevant authorities should work to increase public awareness about the dangers of improper antibiotic use in poultry farming, which will significantly contribute to reducing the emergence of multidrug-resistant bacteria and promoting responsible antibiotic practices.

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