Scientific Research Publishing

Advances in Microbiology, 2026, 16(11), 489-507
https://www.scirp.org/journal/aim
ISSN Online: 2165-3410
ISSN Print: 2165-3402

# Antimicrobial Susceptibility of *Escherichia coli* and *Salmonella* spp. Isolated from Selected Peri-Urban Poultry Farms in Coyah, Republic of Guinea

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**How to cite this paper:** Diallo, A.D., Diallo, M., Diallo, S., Boiro, A., Balamou, O.-O., Makanera, A. and Bah, B.S.S. (2026) Antimicrobial Susceptibility of *Escherichia coli* and *Salmonella* spp. Isolated from Selected Peri-Urban Poultry Farms in Coyah, Republic of Guinea. *Advances in Microbiology*, **16**, 489-507.
https://doi.org/10.4236/aim.2026.1611029

**Received:** October 24, 2026
**Accepted:** November 15, 2026
**Published:** November 18, 2026

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## Abstract

Poultry farms constitute important reservoirs of Enterobacterales, particularly *Escherichia coli* and *Salmonella* spp., which are frequently associated with foodborne infections. This study aimed to assess antimicrobial resistance among bacterial strains belonging to the genera *E. coli* and *Salmonella* spp. The study was conducted from July to November 2024 on six poultry farms. A total of 130 samples were collected, comprising 105 fresh-dropping samples and 25 cloacal swabs. Bacterial identification was performed using selective culture media, followed by biochemical confirmation with the API 20E system. Antimicrobial susceptibility was assessed using the disk diffusion method on agar. Among the samples analyzed, the positivity rates for *E. coli* were 52.38% in fresh-dropping samples and 36.00% in cloacal swabs, whereas those for *Salmonella* spp. were 13.33% and 12.00%, respectively. Antimicrobial susceptibility testing revealed that 100% of the *E. coli* isolates were resistant to at least two antibiotics, while the *Salmonella enterica* isolates exhibited resistance to at least three antibiotics. These findings highlight the need to strengthen antimicrobial resistance surveillance and improve poultry farm management practices.

## Keywords

Antimicrobial Resistance, *Escherichia coli*, *Salmonella* spp., Poultry Farms,

Coyah, Guinea

## 1. Introduction

Population migration towards urban centers has led to an increased demand for food, particularly animal-derived proteins, to meet the nutritional needs of growing populations. This urbanization places considerable pressure on several food production sectors, including poultry production systems, in which growth-promoting agents are sometimes used to meet increasing food demand [1]. The intensification of poultry production creates challenges related to flock health, bacterial contamination, and food safety [2]. *Escherichia coli* and *Salmonella* spp. are frequently detected throughout the poultry production chain [3].

These bacteria can spread within poultry farms and contribute to the dissemination of antimicrobial-resistant bacteria throughout the food chain. This situation highlights the interconnection between human, animal, and environmental health within the framework of the One Health approach [4] [5].

Avian colibacillosis is an infectious disease of considerable economic and public health importance. It is primarily caused by pathogenic strains of *Escherichia coli*, commonly referred to as avian pathogenic *Escherichia coli* (APEC). These bacteria can cause various extraintestinal infections in poultry, including septicemia, airsacculitis, pericarditis, and perihepatitis. Some *E. coli* strains may also pose a public health risk because of their zoonotic potential and their ability to carry antimicrobial resistance genes [6].

The presence of *Salmonella* spp. in poultry products, particularly meat, eggs, and their derivatives, has frequently raised concerns regarding their safety for human consumption [7]. These bacteria are responsible for gastrointestinal diseases in humans and animals worldwide [8]. In Mali, the reported prevalence of salmonellosis caused by *S. pullorum* and *S. gallinarum* ranged from 19.53% to 20.09% in organ and egg samples [9].

The discovery of antibiotics initially raised hopes of achieving effective control of infectious diseases. However, the emergence of antimicrobial resistance has gradually challenged this prospect [10].

The rapid emergence and spread of antibiotic-resistant bacteria have further compromised the ability to effectively control infectious diseases [11].

Currently, accurately assessing the economic burden of infectious diseases remains difficult because the quality and accessibility of available data vary considerably [12]. Nevertheless, these diseases can have substantial consequences, particularly for public health. In this context, the One Health approach advocates the use of common indicators across the human, animal, and environmental health sectors to monitor antimicrobial resistance [13].

Although antimicrobial resistance is recognized as a major global health priority within the One Health framework, reliable and up-to-date epidemiological

data remain limited in Guinea, particularly at the prefectural level and in strategically important areas such as Coyah.

To help address this information gap, the present study was conducted on selected peri-urban poultry farms in Coyah Prefecture.

The objective of this study was to assess antimicrobial resistance among *Escherichia coli* and *Salmonella* spp. strains isolated from selected peri-urban poultry farms in Coyah, Republic of Guinea.

## 2. Materials and Methods

### 2.1. Study Area

Coyah is a town located in the Kindia administrative region, at the foot of Mount Kakoulima, which reaches an altitude of 1107 m, approximately 50 km east of the capital, Conakry. The town occupies a strategic position because of its geographical proximity to Conakry.

Coyah Prefecture is located at 9˚42'01" north latitude and 13˚23'02" west longitude. It is bordered to the north and west by Dubréka Prefecture, to the east by Kindia Prefecture, to the southeast by Forécariah Prefecture, and to the southwest by the Atlantic Ocean and the Conakry area.

The prefecture covers an area of 2166 km$^2$. According to recent demographic estimates and projections based on the Fourth General Population and Housing Census (RGPH-4), its population was estimated at approximately 344,000 inhabitants in 2025 [14], corresponding to a population density of more than 158 inhabitants per km$^2$.

The area is crossed by several major watercourses, including the Toguiron and Wonkifon rivers, as well as the Kouriyah waterfall. These watercourses contribute to the formation of various deltaic ecosystems and wetlands that play an important role in the local economy, particularly in agriculture, livestock farming, energy production, and tourism.

The region has a tropical monsoon climate characterized by two alternating seasons: a rainy season and a dry season. Temperatures generally range from 22˚C to 35˚C. Its proximity to Conakry promotes urbanization and socioeconomic development.

Agriculture and livestock farming are also important economic activities in the rural areas of the prefecture, reflecting the major role of the agricultural sector in the livelihoods of rural populations in Guinea [15].

### 2.2. Study Setting

The Institute of Applied Biology Research of Guinea (IRBAG), which served as the study setting, is located approximately 6 km northwest of the urban municipality of Kindia.

The institute comprises a general directorate, a doctoral program, and six scientific departments: Virology, Clinical Epidemiology, Medical Zoology, Venereology, Food Hygiene, and Bacteriology.

### 2.3. Study Design and Sampling

This was a descriptive study with an analytical component, conducted from July to November 2024.

The study combined field surveys conducted using structured questionnaires with biological sampling for laboratory analyses.

Fresh-dropping samples were collected individually from each poultry farm. Each sample consisted of a fresh dropping originating from a single bird and collected immediately after defecation, while avoiding contact with older droppings, litter, or other potential sources of environmental contamination.

The samples were placed individually in properly labeled sterile tubes and transported to the laboratory under appropriate conditions for microbiological analysis.

### 2.4. Sample Transportation

Samples were transported in an insulated cooler containing ice packs to maintain a temperature of approximately 4˚C. They were delivered to the laboratory for analysis or storage within less than four hours, in accordance with the applicable standard [16].

### 2.5. Biological Material

The biological material consisted of fresh-dropping samples and cloacal swabs.

### 2.6. Laboratory Materials and Equipment

The laboratory materials and equipment mainly included sampling containers, identification labels, disposable gloves, ice packs, Petri dishes, buffered peptone water, Pasteur pipettes, 70% ethanol, an autoclave, a shaker, a refrigerator, a light microscope, microscope slides and coverslips, a colony counter, Eppendorf tubes, sterile inoculating loops, reagents for oxidase and catalase tests, antibiotic disks (bioMérieux), ordinary nutrient agar, Hektoen agar, MacConkey agar, XLD agar, Kligler-Hajna agar, Mueller-Hinton agar, and API 20E identification strips (bioMérieux).

Survey forms were also used to collect information and identify the poultry farms included in the study.

### 2.7. Sample Collection

A total of 130 samples, comprising 105 fresh-dropping samples and 25 cloacal swabs, were collected from six private poultry farms between July and November 2024 (**Table 1**).

As shown in **Table 1**, dropping samples and cloacal swabs were collected from farms F1 to F6 according to the following distribution.

Approximately 12 g of fresh fecal material was collected individually using a sterile applicator fitted with a cotton tip. Each sample corresponded to a dropping originating from a single bird. Droppings were collected immediately after excre-

tion, while avoiding contact with litter, older droppings, or other surfaces that could cause environmental contamination. The collected material was then transferred into a separate, individually labeled sterile tube containing approximately 5 mL of sterile distilled water.

Cloacal swabs were collected from laying hens exhibiting suspected clinical signs, including diarrhea, anorexia, and oral discharge, which were not in the laying period at the time of sampling. These samples were labeled separately and linked to the corresponding farm.

The swabs used in this study consisted of absorbent applicators fitted with cotton tips. Each swab was gently inserted into the hen's cloaca and rotated against the cloacal walls to collect secretions and fecal material.

All samples were labeled before being placed in an insulated cooler containing ice packs to maintain a temperature of approximately 4˚C. They were transported to the laboratory within a maximum period of four hours.

Upon arrival, the samples were stored in a refrigerator and processed the following day.

Each batch of samples collected from a given farm was accompanied by a monitoring form indicating the name of the sampling operator, the sampling date, the age and number of birds in each flock, and any clinical signs suggestive of disease.

**Table 1.** Distribution of samples collected from poultry farms.

| Sites de prelevements | Code fermes | Types de prelevements | |
|---|---|---|---|
| | | X | Y |
| Boundaya | F1 | 18 | 08 |
| Wonkifong | F2 | 16 | 06 |
| Kakoulimaya | F3 | 22 | 0 |
| Tambaya | F4 | 16 | 06 |
| Kourya | F5 | 13 | 05 |
| Kirya | F6 | 20 | 0 |
| Total | **6** | **105** | **25** |

X: Number of fresh-dropping samples; Y: Number of cloacal swabs collected.

## 2.8. Sample Processing

Dropping samples were directly diluted in peptone water, in accordance with the laboratory's analytical procedure, and subsequently inoculated onto culture media.

Contaminated packaging and materials were incinerated or sterilized by autoclaving.

After refrigeration, the cloacal swabs were vigorously shaken to release microorganisms into the peptone water. The swab shaft was then broken, and the tube was tightly closed.

## 2.9. Bacteriological Analysis of Samples

Biological samples collected from poultry farms in Coyah Prefecture underwent bacteriological examination.

### 2.9.1. Detection of *E. coli*

The detection and identification of *E. coli* strains were performed using an in-house procedure developed by the IRBAG Bacteriology Laboratory and adapted to the matrices analyzed.

The procedure consisted of five steps.

**Step 1: Non-selective pre-enrichment**

For each dropping sample, 1 g of fecal material was added to 9 mL of buffered peptone water and homogenized using a V-32 vortex mixer for one minute. Each cloacal swab was placed in a test tube containing 5 mL of buffered peptone water (BPW).

The resulting homogenates were allowed to stand at room temperature for 30 minutes to promote bacterial resuscitation and were then incubated at 37˚C for 18 ± 2 hours.

This sample preparation step was intended to facilitate the dispersion and recovery of bacteria present in the samples.

**Step 2: Presumptive isolation on selective medium**

MacConkey agar (Biokar, France), a selective and differential medium, was used to facilitate the selection of Gram-negative bacteria based on their ability to ferment lactose.

Pink to red colonies, characteristic of lactose fermentation, were considered presumptive *E. coli* colonies and selected for further examination.

**Step 3: Selection and purification of presumptive colonies**

Colonies displaying characteristics compatible with those of *E. coli* were selected and purified to obtain pure bacterial cultures.

**Step 4: Microscopic and biochemical characterization**

The isolates were subjected to Gram staining, as well as oxidase and catalase tests.

The expected characteristics of *E. coli* included a Gram-negative bacillary morphology and a negative oxidase reaction.

**Step 5: Biochemical identification**

Biochemical identification of the isolates was performed using the API 20E system, a miniaturized system based on 20 biochemical tests designed for the identification of Gram-negative bacteria, particularly *E. coli*.

The biochemical profiles obtained were interpreted using the APIWEB system to establish the presumptive identification of the bacterial species isolated.

### 2.9.2. Detection of *Salmonella* spp.

The detection of *Salmonella* spp. in dropping samples and cloacal swabs was performed using an in-house procedure developed by the IRBAG Bacteriology Laboratory and based on the principles of standard NF EN ISO 6579-1:2017 [16].

The procedure consisted of three steps.

**Step 1: Non-selective pre-enrichment**

For each sample, 1 g of fecal material was added to 9 mL of buffered peptone water and homogenized using a laboratory shaker for one minute. Each cloacal swab was then placed in a test tube containing 5 mL of buffered peptone water (BPW).

The homogenates were allowed to stand at room temperature for 30 minutes to promote bacterial resuscitation and were subsequently incubated at 37˚C for 18 ± 2 hours.

This non-selective pre-enrichment step was intended to facilitate the recovery of bacteria potentially present at low concentrations or subjected to stress in the samples.

**Step 2: Presumptive isolation on selective and differential media**

Following non-selective pre-enrichment, the resulting cultures were inoculated onto two complementary selective and differential media: XLD agar (Xylose Lysine Deoxycholate) and Hektoen agar. Colonies displaying morphological characteristics suggestive of *Salmonella* spp. were considered presumptive positive colonies.

These included red colonies with black centers on XLD agar and blue-green colonies with black centers on Hektoen agar. These morphological characteristics were used for the presumptive selection of colonies before biochemical identification.

**Step 3: Biochemical identification**

The API 20E strip is an identification system based on 20 miniaturized biochemical tests used to characterize the metabolic properties of Enterobacterales and other non-fastidious Gram-negative bacilli. It consists of 20 miniaturized biochemical tests arranged in a plastic strip (bioMérieux).

The first step consisted of assembling the base and lid of an incubation box and labeling the tray with the strain identification code. Water was then distributed into the wells using a pipette to create a humid atmosphere.

After the incubation boxes had been prepared and labeled, the cupules were inoculated using a bacterial suspension adjusted to a turbidity equivalent to 0.5 McFarland. Inoculation was performed by placing the pipette tip against the wall of each cupule to avoid bubble formation, which could interfere with the results.

For the ADH, LDC, ODC, H2S, and URE tests, the tube portions were filled with the bacterial suspension and then covered with paraffin oil to create anaerobic conditions. For the CIT, VP, and GEL biochemical tests, both the tubes and cupules were filled with the inoculum, whereas for the remaining tests, filling was restricted to the tube portions.

After incubation at 37˚C for 18 - 24 hours, the API 20E strip was read using the analytical profile index provided with the kit, and the results were confirmed using the APIWEB identification software.

### 2.9.3. Antimicrobial Susceptibility Testing

For each culture-positive sample, one representative bacterial colony displaying

the expected cultural and biochemical characteristics was selected for antimicrobial susceptibility testing.

Accordingly, a single isolate per bacterial species per positive sample was subjected to antimicrobial susceptibility testing using the disk diffusion method on Mueller-Hinton agar with antibiotic disks (bioMérieux).

Each isolate was assigned a unique identification code, allowing its origin to be traced and linked to the corresponding poultry farm.

The results were interpreted in accordance with the recommendations of the Antibiogram Committee of the French Society for Microbiology (CA-SFM) [17].

Mueller-Hinton agar plates were inoculated with bacterial suspensions prepared from Kligler-Hajna agar slants. The inoculum was diluted 1:1000 to obtain an estimated concentration equivalent to ($10^6$) CFU/mL.

The plates were incubated at 37˚C for 18 - 20 hours before reading.

Inhibition zone diameters were measured, and the results were interpreted according to the criteria established by the Antibiogram Committee of the French Society for Microbiology [18].

The following antibiotics were tested: ampicillin (AMP10), gentamicin (CN10), trimethoprim-sulfamethoxazole (SXT30), ciprofloxacin (CIP5), nitrofurantoin (F300), and azithromycin (AZM30).

### 2.10. Statistical Analysis

Data were collected using specifically designed survey forms.

The Wilson method was used to calculate 95% confidence intervals (95% CIs), as it is suitable for estimating proportions, particularly when sample sizes are relatively small.

Three statistical approaches were used to determine whether the observed differences were statistically significant: Pearson's chi-square test, Fisher's exact test, and comparisons stratified by poultry farm.

The statistical significance threshold was set at 5% ($p < 0.05$). Results were considered statistically significant when the p-value was below this threshold.

## 3. Results

### 3.1. Detection of *Escherichia coli* and *Salmonella enterica* spp.

Bacteriological analysis showed that the overall positivity rate for *E. coli* was 52.38% in fresh-dropping samples, compared with 36.00% in cloacal swabs.

At the farm level, positivity rates in dropping samples ranged from 50.00% to 55.00%. For cloacal swabs, positivity rates ranged from 33.33% to 40.00% in the four farms where this type of sample was collected.

The confidence intervals were relatively wide, particularly for cloacal swabs, indicating considerable uncertainty associated with the small sample size.

These results suggest a higher detection rate of *E. coli* in fresh-dropping samples. However, this descriptive difference is insufficient to establish a statistically significant difference between the two sampling methods.

Pearson's chi-square statistic was 2.168, with a p-value of 0.141, indicating that no statistically significant difference was observed between the overall positivity rates of dropping samples and cloacal swabs according to the chi-square test.

The estimated odds ratio (OR) of 1.96 also failed to demonstrate a statistically significant difference between the two sampling methods.

Furthermore, farms F3 and F6 did not provide any cloacal swab samples. Therefore, they could not be included in a direct comparison between the two sampling methods.

Consequently, the stratified analysis included the four farms for which both types of samples were available: F1, F2, F4, and F5 (Table 2).

In addition, the positivity rates for *Salmonella enterica* were analyzed. A total of 17 samples positive for *Salmonella enterica* were identified among the 130 samples analyzed.

The overall positivity rate for *Salmonella enterica* was 13.33% in fresh-dropping samples, compared with 12.00% in cloacal swabs.

At the farm level, positivity rates in dropping samples ranged from 0% to 25.00%. The highest rate was observed on farm F4 (25.00%), followed by F6 (20.00%) and F3 (13.64%).

For cloacal swabs, positivity rates ranged from 0% to 33.33% in the four farms where this type of sample was collected. The highest rate was also recorded on farm F4 (33.33%).

The confidence intervals were relatively wide, particularly for cloacal swabs, reflecting the considerable uncertainty associated with the small number of samples analyzed (Table 3).

Pearson's chi-square statistic was 0.032, indicating that no statistically significant difference was observed between the overall positivity rates of dropping samples and cloacal swabs (p = 0.859).

Fisher's exact test also revealed no statistically significant difference between the positivity rates of dropping samples and cloacal swabs (p = 1.000).

Table 2. Positivity rates of *E. coli* according to sample type and poultry farm.

| Farm | Positive dropping samples, n/N (%) | 95% CI | Positive cloacal swabs, n/N (%) | 95% CI |
|---|---|---|---|---|
| **F1** | 9/18 (50.00) | 29.0 - 71.0 | 3/8 (37.50) | 13.7 - 69.4 |
| **F2** | 8/16 (50.00) | 28.0 - 72.0 | 2/6 (33.33) | 9.7 - 70.0 |
| **F3** | 12/22 (54.55) | 34.7 - 73.1 | Not collected | — |
| **F4** | 8/16 (50.00) | 28.0 - 72.0 | 2/6 (33.33) | 9.7 - 70.0 |
| **F5** | 7/13 (53.85) | 29.1 - 76.8 | 2/5 (40.00) | 11.8 - 76.9 |
| **F6** | 11/20 (55.00) | 34.2 - 74.2 | Not collected | — |
| Total | **55/105 (52.38)** | **42.9 - 61.7** | **9/25 (36.00)** | **20.2 - 55.5** |

n/N: Number of positive samples/total number of samples analyzed; CI: confidence interval.

**Table 3.** Positivity rates of *Salmonella* spp. according to sample type and poultry farm.

| Farm | Positive dropping samples, n/N (%) | 95% CI | Positive cloacal swabs, n/N (%) | 95% CI |
|---|---|---|---|---|
| **F1** | 3/18 (16.67) | 5.84 - 39.22 | 0/8 (0.00) | 0 - 32.44 |
| **F2** | 0/16 (0.00) | 0 - 19.36 | 1/6 (16.67) | 3.01 - 56.35 |
| **F3** | 3/22 (13.64) | 4.75 - 33.33 | Not collected | — |
| **F4** | 4/16 (25.00) | 10.18 - 49.50 | 2/6 (33.33) | 9.68 - 70.00 |
| **F5** | 0/13 (0.00) | 0 - 22.81 | 0/5 (0.00) | 0 - 43.45 |
| **F6** | 4/20 (20.00) | 8.07 - 41.60 | Not collected | — |
| Total | **14/105 (13.33)** | **8.11 - 21.14** | **3/25 (12.00)** | **4.17 - 29.96** |

n/N: Number of positive samples/total number of samples analyzed; CI: confidence interval.

## 3.2. Antimicrobial Resistance among Pathogenic Enterobacterales Isolated from Poultry Farms

### 3.2.1. Antimicrobial Resistance Profiles of *Escherichia coli*

Analysis of the antimicrobial resistance profiles of the 64 *Escherichia coli* isolates revealed varying resistance proportions depending on the antibiotics tested and the poultry farms investigated.

The highest resistance rates were observed for ampicillin and the trimethoprim-sulfamethoxazole combination, with 100% resistance (95% CI: 94.3 - 100) recorded for each of these two antibiotics.

A similarly high resistance rate was observed for gentamicin, with 61 of the 64 isolates tested being resistant, corresponding to 95.3% (95% CI: 87.1 - 98.4).

Farms F2, F3, F5, and F6 showed 100% resistance, whereas farms F1 and F4 recorded resistance rates of 83.3% (10/12; 95% CI: 55.2 - 95.3) and 90.9% (10/11; 95% CI: 62.3 - 98.4), respectively.

These findings indicate that gentamicin resistance was widespread across all six poultry farms.

In contrast, ciprofloxacin resistance was more moderate, affecting 43.8% of the isolates (28/64; 95% CI: 32.3 - 55.9).

Variations were observed between farms, with resistance rates ranging from 16.7% on farm F6 (1/6; 95% CI: 3.0 - 56.4) to 55.6% on farm F5 (5/9; 95% CI: 26.7 - 81.1).

Farm F3 also showed a relatively high resistance rate of 53.3% (8/15; 95% CI: 30.1 - 75.2), followed by F4 with 45.5% (5/11; 95% CI: 21.3 - 72.0), F1 with 41.7% (5/12; 95% CI: 19.3 - 68.0), and F2 with 36.4% (4/11; 95% CI: 15.2 - 64.6).

These findings highlight a substantial level of fluoroquinolone resistance among the poultry farms investigated.

The overall resistance rate of *E. coli* to azithromycin was 31.2% (20/64; 95% CI: 21.2 - 43.4).

The highest proportion was recorded on farm F4, at 45.5% (5/11; 95% CI: 21.3 - 72.0), whereas farms F1, F2, and F3 showed resistance rates of 25.0% (3/12; 95%

CI: 8.9 - 53.2), 27.3% (3/11; 95% CI: 9.7 - 56.6), and 26.7% (4/15; 95% CI: 10.9 - 52.0), respectively.

Farms F5 and F6 each recorded a resistance rate of 33.3%, corresponding to 3/9 (95% CI: 12.1 - 64.6) and 2/6 (95% CI: 9.7 - 70.0), respectively.

These findings indicate that azithromycin resistance was detected on all six farms, although its frequency varied between farms.

The lowest proportion of resistance was observed for nitrofurantoin (F300), at 6.2% (95% CI: 2.5 - 15.0).

Resistance was detected only on farms F1, F2, and F3, with rates of 8.3% (1/12; 95% CI: 1.5 - 35.4), 9.1% (1/11; 95% CI: 1.6 - 37.7), and 13.3% (2/15; 95% CI: 3.7 - 37.9), respectively.

No nitrofurantoin-resistant isolates were detected on farms F4, F5, or F6 (**Table 4**).

#### 3.2.2. Antimicrobial Resistance Profiles of *Salmonella enterica* Isolates

Analysis of the antimicrobial resistance profiles of the 17 *Salmonella enterica* isolates also revealed varying resistance proportions according to the antibiotics tested.

The highest resistance rates were observed for ampicillin (17/17; 95% CI: 81.6 - 100), gentamicin (100%; 95% CI: 81.6 - 100), and the trimethoprim-sulfamethoxazole combination (100%; 95% CI: 81.6 - 100).

Ciprofloxacin resistance accounted for an overall proportion of 29.4% (5/17; 95% CI: 13.3 - 53.1).

Differences were observed between farms. Farm F4 recorded the highest resistance proportion, at 50.0% (3/6; 95% CI: 18.8 - 81.2), followed by F5 at 33.3% (1/3; 95% CI: 6.1 - 79.2) and F2 at 25.0% (1/4; 95% CI: 4.6 - 69.9).

No ciprofloxacin-resistant isolate was detected on farm F3 (0/4; 95% CI: 0 - 49.0).

These findings indicate that ciprofloxacin resistance was detected on three of the four farms investigated.

Azithromycin resistance was lower, with an overall rate of 41.2% (7/17; 95% CI: 21.6 - 64.0).

Farm F3 showed the highest resistance proportion, at 75.0% (3/4; 95% CI: 30.1 - 95.4), followed by F2 at 50.0% (2/4; 95% CI: 15.0 - 85.0) and F4 at 33.3% (2/6; 95% CI: 9.7 - 70.0).

No azithromycin-resistant isolate was observed on farm F5 (0/3; 95% CI: 0 - 56.1).

The overall nitrofurantoin resistance rate was 76.5% (13/17; 95% CI: 52.7 - 90.4).

Farm F2 recorded 100% resistance (4/4; 95% CI: 51.0 - 100), followed by F3 with 75.0% (3/4; 95% CI: 30.1 - 95.4).

Farms F4 and F5 each showed a resistance proportion of 66.7%, corresponding to 4/6 (95% CI: 30.0 - 90.3) and 2/3 (95% CI: 20.8 - 93.9), respectively.

These findings indicate a substantial proportion of nitrofurantoin resistance across the four farms investigated, in contrast to the patterns observed for ciprofloxacin and azithromycin (**Table 5**).

**Table 4.** Distribution of antimicrobial resistance among *E. coli* isolates according to poultry farm.

| Antibiotic | Farm | Resistant isolates, n/N (%) | 95% CI |
|---|---|---|---|
| **AMP10** | F1 | 12/12 (100) | 75.8 - 100 |
| **AMP10** | F2 | 11/11 (100) | 74.1 - 100 |
| **AMP10** | F3 | 15/15 (100) | 79.6 - 100 |
| **AMP10** | F4 | 11/11 (100) | 74.1 - 100 |
| **AMP10** | F5 | 9/9 (100) | 70.1 - 100 |
| **AMP10** | F6 | 6/6 (100) | 61.0 - 100 |
| **AMP10** | **Total** | **64/64 (100)** | **94.3 - 100** |
| **CN10** | F1 | 10/12 (83.3) | 55.2 - 95.3 |
| **CN10** | F2 | 11/11 (100) | 74.1 - 100 |
| **CN10** | F3 | 15/15 (100) | 79.6 - 100 |
| **CN10** | F4 | 10/11 (90.9) | 62.3 - 98.4 |
| **CN10** | F5 | 9/9 (100) | 70.1 - 100 |
| **CN10** | F6 | 6/6 (100) | 61.0 - 100 |
| **CN10** | **Total** | **61/64 (95.3)** | **87.1 - 98.4** |
| **CIP5** | F1 | 5/12 (41.7) | 19.3 - 68.0 |
| **CIP5** | F2 | 4/11 (36.4) | 15.2 - 64.6 |
| **CIP5** | F3 | 8/15 (53.3) | 30.1 - 75.2 |
| **CIP5** | F4 | 5/11 (45.5) | 21.3 - 72.0 |
| **CIP5** | F5 | 5/9 (55.6) | 26.7 - 81.1 |
| **CIP5** | F6 | 1/6 (16.7) | 3.0 - 56.4 |
| **CIP5** | **Total** | **28/64 (43.8)** | **32.3 - 55.9** |
| **AZM30** | F1 | 3/12 (25.0) | 8.9 - 53.2 |
| **AZM30** | F2 | 3/11 (27.3) | 9.7 - 56.6 |
| **AZM30** | F3 | 4/15 (26.7) | 10.9 - 52.0 |
| **AZM30** | F4 | 5/11 (45.5) | 21.3 - 72.0 |
| **AZM30** | F5 | 3/9 (33.3) | 12.1 - 64.6 |
| **AZM30** | F6 | 2/6 (33.3) | 9.7 - 70.0 |
| **AZM30** | **Total** | **20/64 (31.2)** | **21.2 - 43.4** |
| **F300** | F1 | 1/12 (8.3) | 1.5 - 35.4 |
| **F300** | F2 | 1/11 (9.1) | 1.6 - 37.7 |
| **F300** | F3 | 2/15 (13.3) | 3.7 - 37.9 |
| **F300** | F4 | 0/11 (0) | 0 - 25.9 |
| **F300** | F5 | 0/9 (0) | 0 - 29.9 |
| **F300** | F6 | 0/6 (0) | 0 - 39.0 |
| **F300** | **Total** | **4/64 (6.2)** | **2.5 - 15.0** |
| **SXT30** | F1 | 12/12 (100) | 75.8 - 100 |

Continued

| | | | |
|---|---|---|---|
| **SXT30** | F2 | 11/11 (100) | 74.1 - 100 |
| **SXT30** | F3 | 15/15 (100) | 79.6 - 100 |
| **SXT30** | F4 | 11/11 (100) | 74.1 - 100 |
| **SXT30** | F5 | 9/9 (100) | 70.1 - 100 |
| **SXT30** | F6 | 6/6 (100) | 61.0 - 100 |
| **SXT30** | **Total** | **64/64 (100)** | **94.3 - 100** |

The 95% CIs were calculated using the Wilson method. The limits are expressed as percentages. Abbreviations: AMP10, ampicillin; CN10, gentamicin; CIP5, ciprofloxacin; AZM30, azithromycin; F300, nitrofurantoin; SXT30, trimethoprim-sulfamethoxazole.

Table 5. Antimicrobial resistance profiles of *Salmonella enterica* isolates according to poultry farm.

| Antibiotic | Farm | Resistant isolates, n/N (%) | 95% CI |
|---|---|---|---|
| AMP10 | F2 | 4/4 (100) | 51.0 - 100 |
| AMP10 | F3 | 4/4 (100) | 51.0 - 100 |
| AMP10 | F4 | 6/6 (100) | 61.0 - 100 |
| AMP10 | F5 | 3/3 (100) | 43.9 - 100 |
| AMP10 | **Total** | **17/17 (100)** | **81.6 - 100** |
| CN10 | F2 | 4/4 (100) | 51.0 - 100 |
| CN10 | F3 | 4/4 (100) | 51.0 - 100 |
| CN10 | F4 | 6/6 (100) | 61.0 - 100 |
| CN10 | F5 | 3/3 (100) | 43.9 - 100 |
| CN10 | **Total** | **17/17 (100)** | **81.6 - 100** |
| CIP5 | F2 | 1/4 (25.0) | 4.6 - 69.9 |
| CIP5 | F3 | 0/4 (0) | 0 - 49.0 |
| CIP5 | F4 | 3/6 (50.0) | 18.8 - 81.2 |
| CIP5 | F5 | 1/3 (33.3) | 6.1 - 79.2 |
| CIP5 | **Total** | **5/17 (29.4)** | **13.3 - 53.1** |
| AZM30 | F2 | 2/4 (50.0) | 15.0 - 85.0 |
| AZM30 | F3 | 3/4 (75.0) | 30.1 - 95.4 |
| AZM30 | F4 | 2/6 (33.3) | 9.7 - 70.0 |
| AZM30 | F5 | 0/3 (0) | 0 - 56.1 |
| AZM30 | **Total** | **7/17 (41.2)** | **21.6 - 64.0** |
| F300 | F2 | 4/4 (100) | 51.0 - 100 |
| F300 | F3 | 3/4 (75.0) | 30.1 - 95.4 |
| F300 | F4 | 4/6 (66.7) | 30.0 - 90.3 |
| F300 | F5 | 2/3 (66.7) | 20.8 - 93.9 |
| F300 | **Total** | **13/17 (76.5)** | **52.7 - 90.4** |

**Continued**

| | | | |
|---|---|---|---|
| SXT30 | F2 | 4/4 (100) | 51.0 - 100 |
| SXT30 | F3 | 4/4 (100) | 51.0 - 100 |
| SXT30 | F4 | 6/6 (100) | 61.0 - 100 |
| SXT30 | F5 | 3/3 (100) | 43.9 - 100 |
| SXT30 | **Total** | **17/17 (100)** | **81.6 - 100** |

The 95% CIs were calculated using the Wilson method. The limits are expressed as percentages. Abbreviations: AMP10, ampicillin; CN10, gentamicin; CIP5, ciprofloxacin; AZM30, azithromycin; F300, nitrofurantoin; SXT30, trimethoprim-sulfamethoxazole.

## 4. Discussion

The results of the present study revealed a relatively high level of bacterial contamination on the poultry farms investigated. *E. coli* was detected in a substantial proportion of poultry-derived samples, with positivity rates of 52.38% in dropping samples and 36.00% in cloacal swabs.

The detection of *E. coli* in both types of samples confirms the presence of this bacterium in the intestinal tract of poultry and in fecal material released into their immediate environment. This observation is consistent with the findings of [19], who investigated poultry farms in Kiambu County, Kenya. These authors reported a high prevalence of *E. coli* in poultry and environmental samples, highlighting the potential role of fecal material and contaminated surfaces in bacterial transmission between animals and their environment.

Our results were lower than those reported in the Democratic Republic of the Congo [20] and Tanzania [21], where *E. coli* was detected in 100% of the laying hens and broiler chickens examined on several small-scale poultry farms. They were also lower than the positivity rate reported by [22] in Chad, where *E. coli* was detected at a frequency of 55.23%.

The positivity rate obtained in our study was also lower than that reported by [23] in Nigeria, where *E. coli* was detected in 178 of the 179 cloacal swabs analyzed (99.4%), as well as the rate reported by [5] in Bobo-Dioulasso, Burkina Faso (71.43%).

The predominance of *E. coli* may be explained by its commensal nature within the intestinal microbiota of birds, its ability to acquire and horizontally transfer antimicrobial resistance genes, and the excessive or inappropriate use of antibiotics in poultry production [24] [25].

The overall analysis of contamination by *Salmonella enterica* revealed positivity rates of 13.33% in fresh-dropping samples and 12.00% in cloacal swabs, corresponding to a combined positivity rate of approximately 13.08%.

These positivity rates were higher than those reported in India by [26] (6.36%), in Guinea by [27] (6.06%), and in a meta-analysis conducted by [28] on poultry farms in Ethiopia, which estimated prevalence rates of 8.69% in fresh-dropping samples and 12.90% in cloacal swabs.

Conversely, our results were lower than those reported by [29] (57.2%) in infected chickens in the municipality of Boussouma, Burkina Faso, and by [22] in N'Djamena, Chad (68.33%).

These relatively low positivity rates may be associated with several factors, including improved hygiene conditions on some poultry farms in Coyah and the adoption of enhanced health-monitoring practices following the avian influenza outbreak that occurred in Guinea in 2023.

Antimicrobial susceptibility testing revealed high levels of resistance among the bacterial isolates. Resistance proportions varied according to the antibiotics tested, with 100% resistance to ampicillin (AMP10) and trimethoprim-sulfamethoxazole (SXT30), as well as a very high resistance rate to gentamicin (95.3%).

These findings indicate that, within the bacterial collection investigated, these three antibiotics showed very limited in vitro activity.

In contrast, ciprofloxacin resistance was observed in 43.8% of the isolates (28/64; 95% CI: 32.3 - 55.9), whereas azithromycin resistance accounted for 31.2% (20/64; 95% CI: 21.2 - 43.4) across all poultry farms. Nitrofurantoin showed the lowest resistance rate, at 6.2% (95% CI: 2.5 - 15.0).

A recent meta-analysis conducted in Brazil on poultry-derived *E. coli* isolates, based on 18 studies published between 2017 and 2024, reported pooled resistance rates of 78.45% to ampicillin, 67.5% to trimethoprim-sulfamethoxazole, 60.04% to ciprofloxacin, and 14.98% to gentamicin.

Compared with these findings, the resistance proportions observed in our study were higher for ampicillin (100% versus 78.45%) and trimethoprim-sulfamethoxazole (100% versus 67.5%), but lower for ciprofloxacin (43.8% versus 60.04%) [30].

Our results also revealed high resistance proportions comparable to those reported by [31] (96.51%) and [32] (92.67%).

Antimicrobial susceptibility testing also revealed high levels of resistance among the 17 *Salmonella enterica* isolates obtained from the four poultry farms included in this analysis (F2, F3, F4, and F5).

Ampicillin resistance was one of the main findings of this study. Indeed, all 17 isolates tested were resistant to this antibiotic, corresponding to a resistance proportion of 100% (95% CI: 81.6 - 100).

This observation is consistent with the findings of a recent study conducted on conventional poultry farms in Hossana, Ethiopia, where all 27 *Salmonella* isolates were also resistant to ampicillin (100%) [33].

Another particularly noteworthy finding was the 100% resistance rate to gentamicin (95% CI: 81.6 - 100).

This proportion contrasts sharply with the results of the study conducted in Hossana, in which only 3 of the 27 isolates (11.1%) were resistant to gentamicin, whereas 18 isolates (66.7%) were susceptible and 6 (22.2%) showed intermediate susceptibility [33].

Regarding ciprofloxacin, 5 of the 17 isolates were resistant, corresponding to an

overall resistance proportion of 29.4% (5/17; 95% CI: 13.3 - 53.1).

This proportion was lower than that reported in the Hossana study, in which 14 of the 27 isolates (51.9%) were resistant to this antibiotic [33].

## 5. Conclusions

The present study demonstrated the circulation of Enterobacterales on peri-urban poultry farms in Coyah, particularly among laying hens.

The relatively high prevalence of bacterial isolates belonging to the genera *E. coli* and *Salmonella enterica* highlights the potential role of poultry farms as reservoirs of antimicrobial-resistant bacteria.

The resistance profiles observed against several antibiotics commonly used in human and veterinary medicine, particularly ampicillin, trimethoprim-sulfamethoxazole, and gentamicin, suggest substantial antimicrobial selection pressure within the poultry farms investigated.

Furthermore, notable susceptibility to nitrofurantoin among *E. coli* isolates and to ciprofloxacin among *Salmonella enterica* isolates was observed.

The findings of this study highlight the need to expand the range of antibiotics tested against the isolated microorganisms and to conduct molecular investigations to determine the extent of antimicrobial resistance and the mechanisms responsible for its dissemination within poultry farms in Coyah.

The implementation of an integrated surveillance system taking into account animal, human, and environmental health would contribute to improving the monitoring and control of this phenomenon.

## Author Contributions

Abdoulaye Djibril Diallo, Mohamed Diallo, Aissatou Boiro, Souleymane Diallo, Ouo-Ouo Balamou, Abdoulaye Makanera, and Boubacar Sidy Sily Bah participated in the writing and revision of the manuscript.

## Conflicts of Interest

The authors unanimously declare that they have no conflicts of interest.

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