

Comparative Profile of Antibiotic Susceptibility in *E. coli* and *Salmonella* spp. Strains Isolated from Patients with Acute Intestinal Infections and Broiler Chickens in the Republic of Uzbekistan

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Abstract To monitor the antimicrobial resistance of *Salmonella* spp. and *E. coli* in the context of food safety, it is essential to assess their sensitivity to antimicrobial drugs (AMD) in order to adjust ongoing therapy. This aligns with the “One Health” initiative. **Objective:** To investigate the comparative antibiotic susceptibility of *E. coli* and *Salmonella* spp. strains isolated from patients with acute intestinal infections and from broiler chickens. **Materials and Methods:** A total of 56 *E. coli* and 128 *Salmonella* strains were studied using bacteriological methods at the Reference Laboratory of the Center for Antimicrobial Resistance (CAMR) between 2020 and 2021. **Results:** A high degree of resistance was observed in antibiotics such as Cefotaxime CTX_ED5, Imipenem IPM_ED10, and Ertapenem ETP_ED10 (CV% 141.42) in *E. coli* strains from broiler chickens compared to those from patients. Similarly, *Salmonella* spp. strains from both sources showed significant resistance to Ampicillin AMP_ED10, Amoxicillin-clavulanic acid AUG_ED20, Imipenem IPM_ED10, and Ciprofloxacin CIP_ED5 with CV% values of 92.24%, 97.79%, 93.56%, and 133.7%, respectively. This indicates widespread veterinary use of these drugs. **Conclusion:** *Salmonella* spp. strains from broilers exhibit higher levels of multidrug resistance than those from patients. *E. coli* strains from both sources show significant resistance to multiple antibiotic classes.

Keywords *Escherichia coli*, *Salmonella*

1. Introduction

Salmonella and pathogenic *Escherichia coli* are among the most common foodborne pathogens, affecting millions of people each year, sometimes resulting in severe and even fatal outcomes. Foods most frequently associated with salmonellosis outbreaks include eggs, poultry, and other animal-derived products. Pathogenic *E. coli* is often linked to unpasteurized milk, undercooked meat, and contaminated fresh fruits and vegetables [7].

Antimicrobial resistance (AMR) is one of the major global threats to public health and development. In 2019, bacterial AMR was directly responsible for 1.27 million deaths globally and contributed to an additional 4.95 million deaths [3]. The emergence of resistance is a natural biological response to antimicrobial use, which creates selective pressure that facilitates the selection, survival, and proliferation of resistant strains of microorganisms [1].

E. coli is considered a multidrug-resistant bacterium due

to its high potential for resistance to numerous antibiotics through various mechanisms. This includes the production of β -lactamase enzymes, which confer resistance to β -lactam antibiotics, as well as enzymes that induce resistance to aminoglycosides, quinolones, and others [8]. For instance, in countries reporting to the Global Antimicrobial Resistance Surveillance System (GLASS), the prevalence of resistance to ciprofloxacin ranges from 8.4% to 92.9% for *Escherichia coli* and from 4.1% to 79.4% for *Klebsiella pneumoniae* [9].

Salmonella spp. ranks second only to *Campylobacter* among zoonotic pathogens responsible for human and animal infections. In the European Union (EU), approximately 100,000 cases of salmonellosis are reported annually [5]. *Salmonella* is a leading cause of foodborne outbreaks, often on an international scale. In 2018, about 35% of etiologically confirmed outbreaks (over 1,500 cases) in the EU were attributed to *Salmonella*, accounting for the largest numbers of affected, hospitalized, and deceased individuals [4].

Objective

It is essential to determine the antimicrobial susceptibility of *Salmonella* spp. and *E. coli* strains to optimize therapy and

monitor resistance as part of food safety efforts under the “One Health” initiative [10]. This concept aims to ensure optimal health outcomes for humans, animals, and the environment by promoting sustainable balance among them. It emphasizes the interconnection between these domains to develop novel surveillance and disease control methods. The “One Health” approach covers issues such as antimicrobial resistance, foodborne illnesses caused by unsafe food, and zoonotic diseases—infected diseases caused by microorganisms transmitted between animals and humans.

2. Materials and Methods

To achieve the stated objective, studies were conducted at the “Center for Antimicrobial Resistance (CAMR)” laboratory of the Republican Specialized Scientific and Practical Medical Center for Epidemiology, Microbiology, Infectious and Parasitic Diseases (RSSPMCEMIPD), within the framework of the state grant project ID: PZ 20170928351, titled:

“Development of a System for Forecasting and Preventing the Adverse Effects of Alimentary Factors on Human Health Based on Phenotypic Resistance and Common Antimicrobial Sensitivity Profiles in Microorganisms Isolated from Patients with Diarrhea and Agricultural Animals” (carried out from 03.01.2018 to 31.12.2020).

Morphological, tinctorial, and biochemical properties of *Salmonella* spp. and *E. coli* strains were studied in accordance with WHO protocols and ISO 6579 standards [2,7].

Biochemical activity was assessed by inoculating cultures into semi-liquid media containing various carbohydrates, alcohols, and amino acids: glucose, mannitol, dulcitol, urea, arabinose, xylose, citrate, acetate, malonate, phenylalanine, and lysine. Indole formation was determined using Morrel’s

reagent in broth cultures.

Antimicrobial susceptibility was assessed using the disk diffusion method according to EUCAST guidelines for 2020–2021 (versions 10.0–11.0). The results were interpreted based on the same EUCAST recommendations [6]. Mueller-Hinton agar (GEETA PHARMA, India) and antibiotic disks (Liofilchem, Italy) were used in the tests. Disk diffusion was the method applied to evaluate susceptibility. *Salmonella* and *E. coli* were tested for susceptibility to the following antimicrobial drugs: β -lactams: ampicillin, amoxicillin/clavulanic acid, cefotaxime, ceftazidime, imipenem, meropenem, ertapenem, doripenem, quinolones: ciprofloxacin, other classes: chloramphenicol, trimethoprim-sulfamethoxazole. For internal quality control, the reference strain *E. coli* ATCC 25922 was used.

3. Results and Discussion

A total of 28 *E. coli* and 37 *Salmonella* spp. strains were isolated from broiler chicken carcasses (samples were collected from a poultry farm during slaughter), and 28 *E. coli* and 91 *Salmonella* strains were isolated from patients with acute intestinal infections (AII) hospitalized at RSSPMCEMIPD.

To assess differences in resistance frequencies between *E. coli* and *Salmonella* spp. strains from broiler chickens and those from patients with AII, statistical analysis was performed. Strains with moderate or high resistance were grouped under the category “non-susceptible.”

Tables 1 and 2 present the zones of growth inhibition for the microorganisms against various antimicrobial agents, along with 95% confidence intervals (CI) and coefficients of variation (CV%) to compare isolates from different sources (*E. coli* from broilers vs. patients; *Salmonella* spp. from broilers vs. patients).

Table 1. Antimicrobial Susceptibility of *E. coli* Strains Isolated from Broiler Chickens and AII Patients

Antibiotic name	Antibiotic Resistance in <i>E. coli</i> from Broilers (%) (n=28)	Resistance in <i>E. coli</i> from Patients (%) (n=28)	CV%	CI%
	R %	R %		
Ampicillin AMP_ED10	96,4	85,7	8,31	6-20
Amoxicillin clavulanic acid AUG_ED20	96,4	85,7	8,31	6-21
Cefotaxime CTX_ED5	0,0	71,4	141,42	6-29
Ceftazidime CAZ_ED10	53,6	96,4	40,35	6-27
Imipenem IPM_ED10	10,8	0,0	141,42	17-30
Meropenem MEM_ED10	0,0	0,0	0	20-32
Ertopenem ETP_ED10	0,0	7,1	141,42	24-32
Doripenem DOR_ED10	46,4	50,0	5,28	16-31
Ciprofloxacin CIP_ED5	96,4	50,0	44,82	6-29
Chloramphenicol CHL_ED30	46,4	14,2	75,14	6-28
Trimethoprim/sulfamethoxazole SXT_ED1.2	100,0	64,2	30,83	6-26

Note: 95% confidence interval (CI) represents the range within which the true resistance value lies with 95% probability.

Table 2. Antimicrobial Susceptibility of Salmonella spp. Strains Isolated from Broiler Chickens and All Patients

Antibiotic name	Antibiotic Resistance in Salmonella spp. from Broilers (%) (n=37)	Resistance in Salmonella spp. from Patients (%) (n=91)	CV%	CI%
	R %	R %		
Ampicillin 10	78,4	16,5	92,24	6-20
Amoxicillin clavulanic acid AUG 20	78,4	14,3	97,79	6-26
Cefotaxime CTX_ED5	5,4	16,5	71,68	6-29
Ceftazidime CAZ_ED10	5,4	16,5	71,68	6-29
Imipenem IPM_ED10	5,4	1,1	93,56	12-31
Meropenem MEM_ED10	0,0	0,0	0,0	24-30
Ertopenem ETP_ED10	0,0	0,0	0,0	28-31
Doripenem DOR_ED10	0,0	0,0	0,0	24-30
Ciproflxacin CIP_ED5	78,4	2,2	133,7	14-30
Chloramphenicol CHL_ED30	78,4	22,0	79,44	6-28
Trimethoprim/sulfamethoxazole SXT_ED1.2	78,4	16,5	92,24	6-28

Note: 95% confidence interval (CI) represents the range within which the true resistance value lies with 95% probability.

From Table 1, the following can be concluded: *E. coli* strains from broiler carcasses showed resistance to β -lactam antibiotics: ampicillin AMP_ED10 – 96.4%, amoxicillin/clavulanic acid AUG_ED20 – 96.4%, ceftazidime CAZ_ED10 – 53.6%, but were susceptible to cefotaxime CTX_ED5. Patient-derived *E. coli* strains showed resistance to ampicillin AMP_ED10 – 85.7%, amoxicillin/clavulanic acid AUG_ED20 – 85.7%, cefotaxime CTX_ED5 – 71.4%, and ceftazidime CAZ_ED10 – 96.4%.

Among carbapenems: Broiler-derived *E. coli* were sensitive to ertapenem ETP_ED10; 46.4% were resistant to doripenem DOR_ED10; 10.8% resistant to imipenem IPM_ED10. Patient-derived *E. coli* were sensitive to imipenem IPM_ED10; resistance to ertapenem ETP_ED10 – 7.1%, doripenem DOR_ED10 – 50.0%. All *E. coli* strains were sensitive to meropenem MEM_ED10.

High resistance to ciprofloxacin was observed in broiler strains (96.4%) versus 50.0% in patient strains. Resistance to chloramphenicol CHL_ED30 and trimethoprim/sulfamethoxazole SXT_ED1.2 was also higher in broiler isolates: 46.4% vs. 14.2%, and 100.0% vs. 64.2%, respectively.

ANOVA and confidence interval analysis showed statistically significant resistance differences between groups for: Cefotaxime CTX_ED5, Imipenem IPM_ED10, Ertapenem ETP_ED10 (CV% 141.42). Moderate to high resistance was common for Ampicillin AMP_ED10, Amoxicillin/clavulanic acid AUG_ED20, Ciprofloxacin CIP_ED5, Ceftazidime CAZ_ED10, and Trimethoprim/Sulfamethoxazole SXT_ED1.2 (CV% 23.07 to 44.82), indicating widespread use in both clinical and veterinary settings. Meropenem MEM_ED10 had 0% variation (high stability across groups). Doripenem DOR_ED10 showed the smallest gap (CV% 5.28).

From Table 2, the following observations can be made: *Salmonella* spp. strains from broiler carcasses showed: high resistance to ampicillin and amoxicillin/clavulanic acid AUG_ED20 (78.4%), low resistance to cefotaxime CTX_ED5 and ceftazidime CAZ_ED10 (5.4%). Strains from patients showed: resistance to ampicillin AMP_ED10 – 16.5%, amoxicillin/clavulanic acid AUG_ED20 – 14.3%, cefotaxime CTX_ED5 and ceftazidime CAZ_ED10 – 16.5%.

All tested *Salmonella* spp. strains were fully sensitive to meropenem MEM_ED10, ertapenem ETP_ED10, and doripenem DOR_ED10. Minor resistance to imipenem IPM_ED10 was observed: 5.4% in broilers and 1.1% in patients.

High resistance to ciprofloxacin was observed in broiler strains (78.4%) compared to patient strains (2.2%). Chloramphenicol CHL_ED30 and trimethoprim/sulfamethoxazole SXT_ED1.2 resistance was also significantly higher in broiler isolates: 78.4% vs. 22.0% (chloramphenicol CHL_ED30), 78.4% vs. 16.5% (trimethoprim/sulfamethoxazole SXT_ED1.2).

Statistical analysis of Table 2 shows: high statistical significance in resistance differences for Ampicillin AMP_ED10, Amoxicillin/clavulanic acid AUG_ED20, Imipenem IPM_ED10, and Ciprofloxacin CIP_ED5, with CV% values of 92.24%, 97.79%, 93.56%, and 133.7%, respectively. This likely reflects extensive use of these antibiotics in veterinary medicine. Moderate resistance to cefotaxime CTX_ED5 and ceftazidime CAZ_ED10 among patient strains (16.5%) and low resistance among broiler strains (5.4%), with CV% of 71.68, indicates statistically significant intergroup differences. Less pronounced variation was seen for chloramphenicol CHL_ED30 and trimethoprim/sulfamethoxazole SXT_ED1.2 (CV% of 79.44 and 92.24, respectively). Carbapenem antibiotics (meropenem MEM_ED10, ertapenem ETP_ED10,

doripenem DOR_ED10) remain effective against both groups and can be considered as reserve drugs.

4. Conclusions

The absence of regulation and widespread use of antibiotics in clinical practice leads to the development of bacterial resistance to antimicrobial agents. Bacteria employ a variety of resistance mechanisms to protect themselves. Acquired resistance arises from mutations, gene transfer through conjugation or transformation, transposons, and bacteriophages. It is essential to determine bacterial resistance across all classes of antibiotics (phenotypic analysis), as well as identify genetic mutations responsible for resistance (genotypic analysis). A deeper understanding of the mechanisms of antibiotic action, the chromosomal locations of resistance genes, and their expression would enable the development of screening and control strategies necessary to reduce the spread and evolution of resistant bacteria.

A statistically significant level of resistance was observed for antibiotics such as Cefotaxime CTX_ED5, Imipenem IPM_ED10, and Ertapenem ETP_ED10 with a CV% of 141.42 when comparing *E. coli* strains from broiler chickens and those from patients with acute intestinal infections. The frequency of resistant *Salmonella* spp. strains from different sources also demonstrated significant resistance to Ampicillin 10, Amoxicillin/clavulanic acid AUG 20, Imipenem IPM_ED10, and Ciprofloxacin CIP_ED5, with CV% values of 92.24%, 97.79%, 93.56%, and 133.7%, respectively. This indicates high statistical reliability and reflects the extensive use of these antibiotics in veterinary medicine. Thus, *Salmonella* spp. strains isolated from broiler chickens exhibit higher levels of multidrug resistance than strains isolated from patients with acute intestinal infections. *E. coli* strains, whether isolated from broilers or patients, show high resistance to multiple classes of antibiotics.

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