Antimicrobial resistance in *Escherichia coli* and *Salmonella* isolated from a broiler supply chain and its environment

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OBJECTIVE: The emergence of AMR has significant global health effects. Indiscriminate use of antimicrobials results in the selection of antimicrobial resistance (AMR) in enteric bacteria of the broiler chicken supply chain. This study aimed to evaluate AMR in two important enteric bacteria *Salmonella* and *Escherichia coli* (*E. coli)* isolated from a broiler supply chain and its environment in Bengaluru, India.

METHODS: Samples were collected from broiler breeder farms (BBFs), hatcheries, commercial broiler farms (CBFs), and retail meat shops (RMSs) from three different broiler chicken integrators, and in each integration, the sample batch was tracked from BBF until it reached RMS. Broiler farms were randomly selected from all healthy farms in the area where no outbreaks of any bacterial infections were recorded. The samples were cultured to identify *E. coli* and *Salmonella*, and disk diffusion and minimum inhibitory concentration (colistin only) methods were used to investigate the presence of AMR phenotypes. Pairwise correlation coefficients among antimicrobial resistances were calculated. Clustering dendrograms were constructed using the single-linkage clustering method and were illustrated in heatmaps.

RESULTS: A total of 106 *Salmonella* and 219 *E. coli* were isolated. The overall prevalence of *Salmonella* and *E. coli* in the complete poultry supply chain was 20% and 71.55%, respectively. A significantly higher ($P<0.05$) presence of *Salmonella* was observed in RMS (46%), followed by CBF (19%) and hatcheries (10%). *Salmonella* and *E. coli* isolates were resistant to at least one antibiotic in the study. Seventy-six and seventy-five percent of *Salmonella* and *E. coli* isolates were multidrug-resistant (MDR) and 17 and 41% were Extended Spectrum Beta-Lactamase (ESBL) producers, respectively. Among *Salmonella* isolates from the entire broiler supply chain, highest resistance was observed to doxycycline (94.34%) followed by ciprofloxacin (73%), gentamicin (65%), enrofloxacin (61%), amikacin (35%), ampicillin (34%), neomycin (33), colistin

(32%), cefotaxime (30%), ceftazidime (29%), trimethoprim-sulfamethoxazole (24%), amoxicillin + clavulanic acid (22%), and chloramphenicol (12%). In *E. coli* isolates the highest resistance was observed to doxycycline (97%) followed by, ciprofloxacin (797%), ampicillin (69%) enrofloxacin (60%), cefotaxime (56%) gentamicin (56%), ceftazidime (54%), trimethoprim-sulfamethoxazole (47%), colistin (42%), amoxicillin + clavulanic acid (40%), amikacin (34%), chloramphenicol (23%) and neomycin (22%). A significantly high pairwise correlation between resistances to several antimicrobials among both the *E. coli* and *Salmonella* isolates were observed. The clustering dendrogram for AMR in *Salmonella* isolates revealed three main cluster patterns i) resistance to gentamicin, ciprofloxacin, and doxycycline, ii) resistance to ceftazidime, cefotaxime, neomycin, and amikacin iii) resistance to chloramphenicol, colistin, trimethoprim-sulfamethoxazole, amoxicillin-clavulanic acid, and ampicillin. The *E. coli* isolates showed two main cluster patterns of resistance i) resistance to ciprofloxacin, doxycycline, gentamicin, ampicillin, ceftazidime, and cefotaxime ii) resistance to neomycin, chloramphenicol, colistin, amikacin, amoxicillin-clavulanic acid, and trimethoprim-sulfamethoxazole.

CONCLUSIONS: Antimicrobial-resistant *E. coli* and *Salmonella* were present throughout the poultry supply chain; however, CBF and RMS were the major focal points of AMR. The presence of resistant isolates and coresistance among several antimicrobials in all parts of the supply chain indicates the need for efficient monitoring and control strategies for the effective prevention of AMR in the complete broiler supply chain.

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