Characterization of Multidrug-Resistant *Salmonella enterica* Serovar Heidelberg from a Ground Turkey-Associated Outbreak in the United States in 2011

Salmonella enterica serotype Heidelberg is the fifth-most-common serotype that causes human disease in the United States, and it appears to be more invasive than other nontyphoidal serotypes (3, 6). In March 2011, a multistate outbreak of *Salmonella enterica* serotype Heidelberg infections was investigated (2). Pulsed-field gel electrophoresis (PFGE) analysis of isolates from suspected cases and an epidemiologic investigation identified 136 case patients from 34 states from February to September. Two closely related XbaI PFGE patterns were identified among the outbreak isolates. Additional information was available on 94 ill persons. Their ages ranged from <1 to 90 years of age, and the median age was 23. Thirty-nine percent of patients were hospitalized. One death was reported. A collaborative effort by national, state, and local agencies identified ground turkey as the source of infection. *S. enterica* serotype Heidelberg isolates matching the outbreak pattern were identified among ground turkey products from retail establishments, and these products originated from a common food production establishment (2).

Nineteen outbreak isolates from ill persons or retail meat samples were sent to the National Antimicrobial Resistance Monitoring System (NARMS) at Centers for Disease Control (CDC) for antimicrobial susceptibility testing (AST). MICs were determined for amikacin, ampicillin, amoxicillin-clavulanic acid, cefoxitin, ceftiofur, ceftriaxone, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfisoxazole, tetracycline, and trimethoprim-sulfamethoxazole by broth microdilution (Sensititre; Trek Diagnostics, Westlake, OH). Resistance was defined by the Clinical and Laboratory Standards Institute (CLSI) interpretive standards, when available (5). For streptomycin, where no CLSI interpretive criteria for human isolates exist, the resistance breakpoint is 64 mg/liter. All of the isolates were resistant to ampicillin, gentamicin, streptomycin, and tetracycline (5). Two isolates from Ohio, one clinical and one retail meat, with different XbaI PFGE patterns (JF6X01.0058 and JF6X01.0032) but the same BlnI pattern (JF6A26.0076) were analyzed for antimicrobial resistance genes by PCR and DNA sequencing. Both isolates were positive for *bla*_{TEM-1}, *aac*(3)-IIa, *aadA1*, *ant*(3'')-Ia, and *tetA* genes (4). Plasmid DNA was electroporated into *E. coli* DH10B cells (7). PCR analysis and AST demonstrated the transfer of all five genes, confirming that they were plasmid encoded. PCR-based replicon typing identified the plasmid as type IncI1, a common poultry-associated plasmid type (1, 8). Plasmid PFGE confirmed plasmids of approximately 100 kb in size in both transformants, and plasmid multilocus sequence typing (pMLST) identified them as sequence type 26 (ST26) (10). Most ST26 plasmids submitted to the pMLST database are cephalosporin resistance plasmids in *Escherichia coli* strains isolated from porcine and human sources in Europe. Conjugation experiments demonstrated that both plasmids were transferred to *E. coli* J53 (sodium azide-resistant) cells with high efficiency (2.8×10^{-1} and 9.0×10^{-2}), similar to IncI1 plasmids from other studies (9, 12).

Both the number of cases and the percentage of hospitaliza-

tions (39%, compared to an average of 26.2% for outbreaks of Heidelberg infections) have raised questions concerning whether the severity of this outbreak was due to pathogen dose or if this multidrug-resistant outbreak "strain" was novel (11). While these isolates do not match previously studied Heidelberg isolates in our laboratory by PFGE, resistance gene content, and plasmid type, NARMS has identified several isolates from past routine surveillance of isolates from ground turkey, turkey, and human clinical samples that match the observed characteristics, including XbaI PFGE pattern, AST pattern, and plasmid characteristics (AR genes, Inc type, ST, and size) (7, 13).

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Address correspondence to Jason P. Folster, gux8@cdc.gov.

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Jason P. Folster

G. Pecic

R. Rickert

J. Taylor

Division of Foodborne, Waterborne, and Environmental Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

S. Zhao

Division of Animal and Food Microbiology, Office of Research, Center for Veterinary Medicine, U.S. Food and Drug Administration, Laurel, Maryland, USA

P. J. Fedorka-Cray

Bacterial Epidemiology and Antimicrobial Resistance Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Athens, Georgia, USA

J. Whichard

Division of Foodborne, Waterborne, and Environmental Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

P. McDermott

Division of Animal and Food Microbiology, Office of Research, Center for Veterinary Medicine, U.S. Food and Drug Administration, Laurel, Maryland, USA