E. coli on U.S. Beef Cow-calf Operations
NAHMS Beef 2017 Study
Information Brief

March 2023

INTRODUCTION

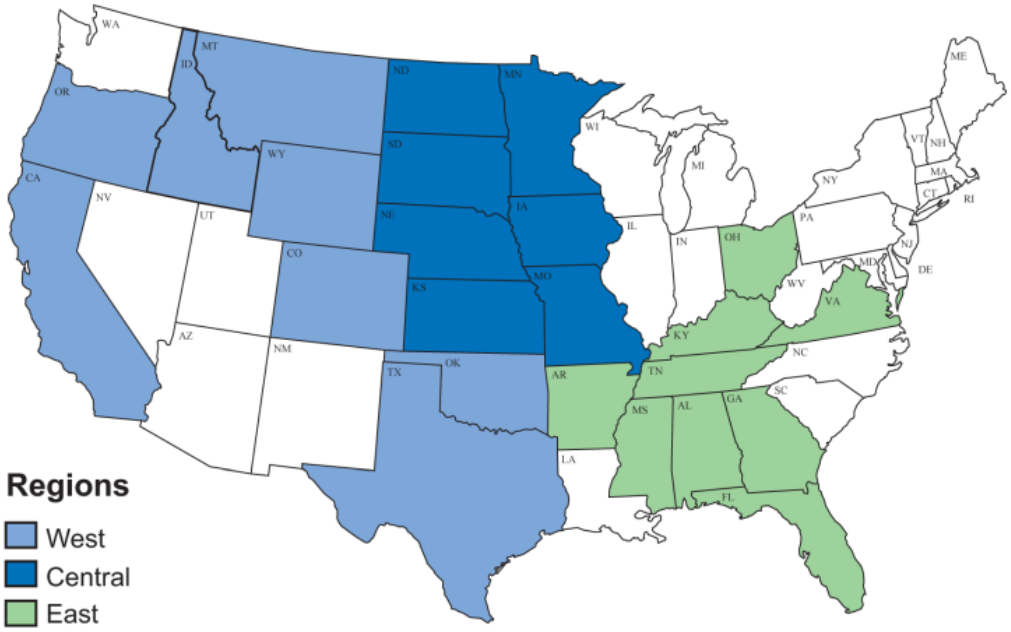
Escherichia coli is a gram-negative bacterium and a common inhabitant of human and animal gastrointestinal tracts. In beef cattle, *E. coli* is typically harmless, but some strains can cause diarrhea in young calves. In humans, most strains of this organism are also harmless, but certain *E. coli* strains can cause illness. In cattle, the most important strains are those that produce Shiga toxins (STECs), such as *E. coli* O157:H7; cattle are considered reservoirs for these organisms (Persad and LeJeune, 2014). Human infections with STECs can be symptom-free or they can cause diarrhea, hemorrhagic colitis (bloody diarrhea), or hemolytic uremic syndrome, which can lead to kidney failure. Occasionally, STEC infections can cause death, especially in children, the elderly, or immunosuppressed persons (Khalil et al., 2018). The main sources of foodborne STEC outbreaks in humans are raw or undercooked ground meat products, raw (unpasteurized) milk, and fecal contamination of vegetables (FDA, 2019).

Many bacteria, including *E. coli*, can acquire resistance to the antimicrobials used to treat bacterial infections. Since *E. coli* are common in both animals and humans, there is concern that these antimicrobial resistance traits could be transferred to other bacteria, such as *Salmonella*, that more commonly cause human illness.

NAHMS BEEF 2017 STUDY

The U.S. Department of Agriculture's National Animal Health Monitoring System (NAHMS) conducted the Beef 2017 study in 24 of the Nation's major cow-calf States (Figure 1). Operations in these States accounted for 86.6 percent of the U.S. beef cow inventory and 78.9 percent of all U.S. operations with beef cows. All operations in these States with one or more beef cows as of January 1, 2017, were eligible to be selected for inclusion in the study. One of the study objectives was to describe antimicrobial resistance (AMR) profiles of *E. coli* on U.S. beef cow-calf operations, though the *E. coli* were not serotyped in order to identify *E. coli* O157:H7 or other serotypes. *E. coli* are expected in most fecal samples, so prevalence of the organism is considered unimportant when serotyping is not performed.

Figure 1. States/Regions that participated in the NAHMS Beef 2017 study



BIOLOGICAL SAMPLING

For the Beef 2017 study, up to 12 composite fecal samples (samples taken from different sites and combined) were collected per operation, with 6 samples from adult cow areas and 6 samples from calf areas. For the adult cow samples, up to six areas on a farm (for example, near a water source or feeding grounds, in calving pens, in an open field or pasture were selected. Adult cow feces from six sites within each area were collected and combined into a composite sample. As an example, if one of the composite samples was from an area near a water source, that sample consisted of feces combined from six sites near that water source. If calves were also present on the operation, the same process sampled up to six areas where calves were known to congregate, with each composite sample consisting of calf feces from six sites within each area.

All the composite fecal samples were tested for *Salmonella*, and a subset of the composite fecal samples (approximately two adult cow samples and two calf samples from each operation) were cultured for *E. coli* at the USDA Agricultural Research Service's Bacterial Epidemiology and Antimicrobial Resistance (ARS BEAR) lab. *E. coli* were cultured from fecal samples by streak-plating 100ul-aliquots of fecal dilutions (1:9 wt/vol, in BPW) onto CHROMagar™ ECC (DRG International) plates. The plates were incubated for 18–24 hours at 37°C. An individual presumptive *E. coli* colony was picked from each plate and replated onto CHROMagar twice to ensure pure growth. *E. coli* isolates were confirmed with indole testing (Tryptone water and Kovac reagent, Sigma) and then stored on Tryptic Soy agar slants until antimicrobial susceptibility testing (AST) was performed.

All *E. coli* isolates were sent to the National Veterinary Services Laboratories (NVSL) for AST, which was performed by plating bacteria on the National Antimicrobial Resistance Monitoring System's (NARMS) gram negative CMV4AGNF AST microtiter plates (Thermo Fisher Scientific). The testing was performed according to Sensititre protocols. Results were interpreted using the 2012 NARMS retail meat breakpoints (NARMS, 2020).

Results from the NAHMS Beef 2007–08 study are also included in this information brief. For the Beef 2007–08 study, up to 10 fresh fecal samples from individual adult cow fecal pats from each operation were cultured for *E. coli*. While this sampling strategy was different from that used in the Beef 2017 study, the fecal culture media (CHROMagar™) was the same and methods of isolation were very similar. Further details of the methodology are published elsewhere (USDA, 2012).

PRESENCE OF *E. COLI*

For the Beef 2017 study, a total of 419 samples were cultured for *E. coli:* 279 were from adult cow areas and 140 were from calf areas (Table 1). These samples came from 136 operations, with 135 of the operations having at least one positive *E. coli* sample. At the operation level, the Beef 2017 prevalence (99.3 percent of operations positive) was similar to the Beef 2007–08 prevalence (99.4 percent of operations positive). Only one *E. coli* isolate was cultured, confirmed, and AST-tested from each sample in both studies. In Beef 2017, *E. coli* was found in 391/419 samples (93.3 percent), which contrasts with Beef 2007–08, where *E. coli* was found in 1,147/1,479 samples (77.6 percent).

The higher prevalence at the sample level in the Beef 2017 study was likely due to the change in sampling methods. In Beef 2007–08, each sample represented one cow. In Beef 2017, each sample represented six or more cows or calves, which resulted in a greater likelihood that at least one of the animals was shedding *E. coli*. The overall high prevalence of *E. coli* on cow-calf operations was not surprising since *E. coli* is a common microbe in the gastrointestinal tracts of humans and animals.

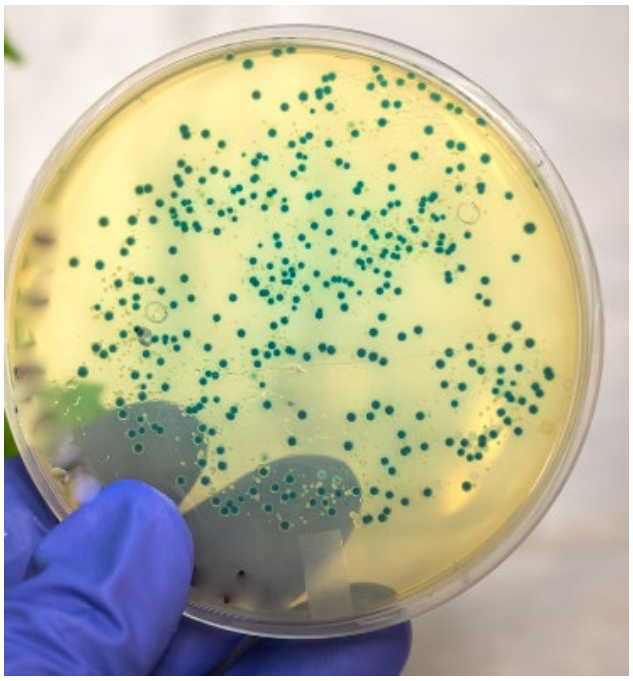


Table 1. Number and percentage of operations and samples positive for *E. coli*

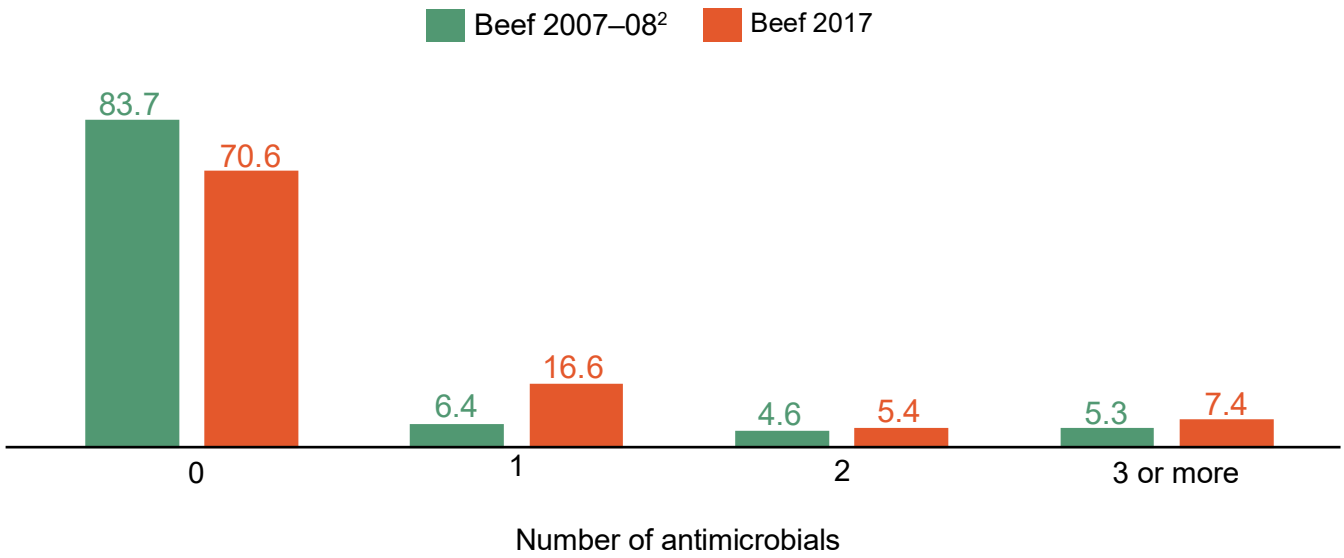
Scope	Study			
	Beef 2007-08		Beef 2017	
	No. Positive/ No. Sampled	Pct.	No. Positive/ No. Sampled	Pct.
Operations				
Total	172/173	99.4	135/136	99.3
Samples				
Adult cow	1,147/1,479	77.6	257/279	92.1
Calf	NA[1]	NA[1]	134/140	95.7
Adult cow and calf	–	–	391/419	93.3

[1]In Beef 2007-08, calf samples were not collected.

ANTIMICROBIAL SUSCEPTIBILITY

A single isolate from every positive *E. coli* fecal sample in the Beef 2017 study underwent antimicrobial susceptibility testing. In total, 276 of the 391 isolates (70.6 percent) were susceptible to all 14 antimicrobials (Figure 2). Only 7.4 percent of isolates were resistant to three or more individual antimicrobial drugs. The maximum number of antimicrobials to which any isolate was resistant was twelve. In the Beef 2007–08 study, 83.7 percent of isolates were susceptible to all 15 antimicrobials tested, and 5.3 percent of isolates were resistant to 3 or more drugs. In both the Beef 2017 and Beef 2007–08 studies, all the antimicrobials in the susceptibility panel are considered medically important (FDA, 2003).

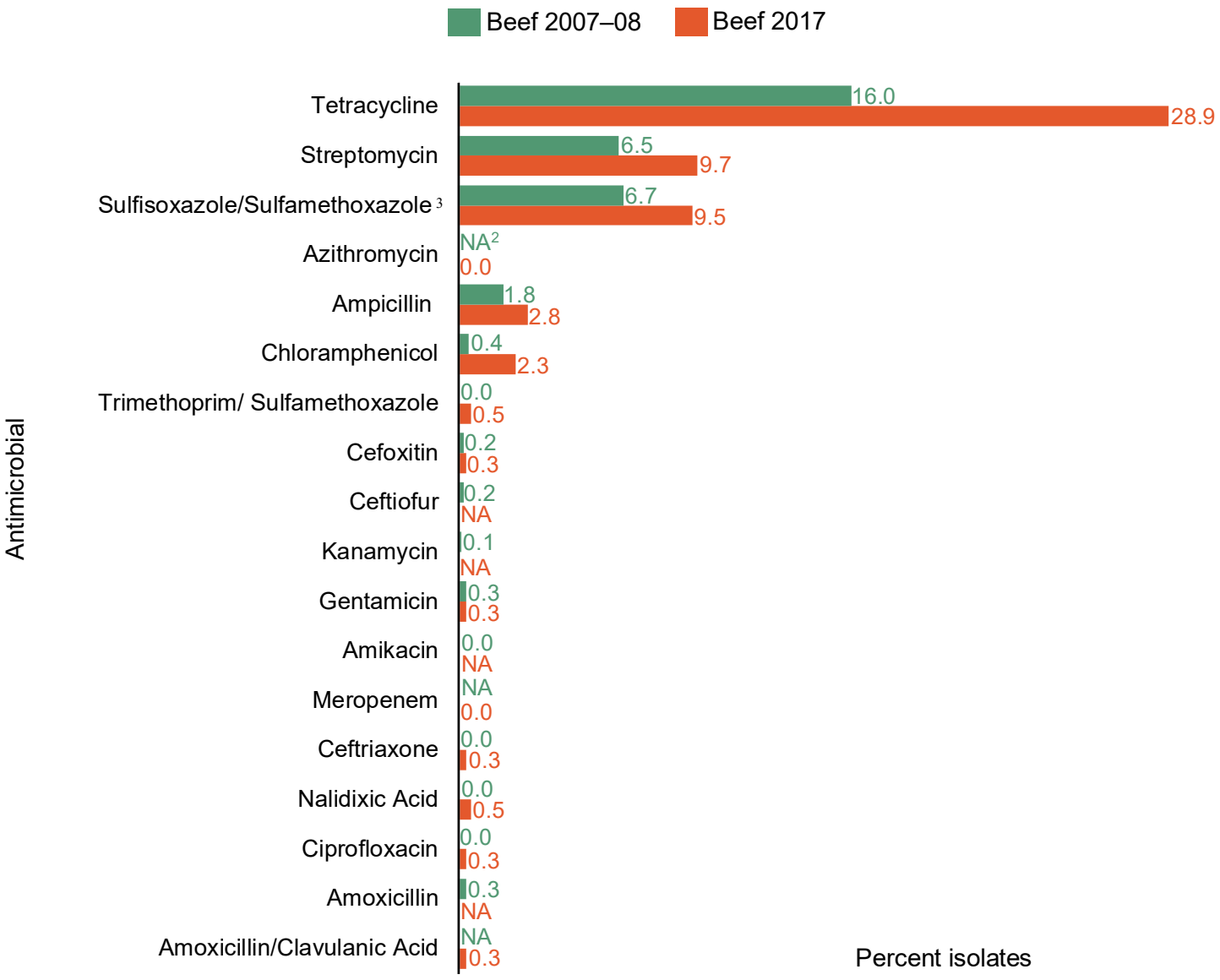
Figure 2. For adult cow isolates in Beef 2007–08 and adult cow and calf isolates in Beef 2017, percentage of *E. coli* isolates[1] by number of antimicrobials to which the isolate was resistant, and by study



[1]The number of isolates equals the number of positive samples since only one *E. coli isolate* was evaluated in each sample.
[2]For Beef 2007–08, one positive sample did not undergo AST. The specific antimicrobials tested in Beef 2007–08 differed from those in Beef 2017. See Figure 3 for a list of the antimicrobials tested in each study.

Of the 14 antimicrobials tested in the Beef 2017 study, there was some resistance found to all but two: azithromycin and meropenem (Figure 3). The most common resistance was to tetracycline, with 28.9 percent of isolates being resistant across 51.9 percent of operations (operation data not shown). There was a low amount of resistance to streptomycin (9.7 percent of isolates across 20.0 percent of operations) and sulfisoxazole (9.5 percent of isolates across 21.5 percent of operations). Resistance to ampicillin was found in 2.8 percent of isolates across 6.7 percent of operations, while resistance to chloramphenicol was found in 2.3 percent of isolates across 4.4 percent of operations. For all other antimicrobials tested, there were a minimal number of resistant *E. coli* isolates found. The observed resistance to amoxicillin/clavulanic acid, cefoxitin, ceftriaxone, ciprofloxacin, and gentamicin was from a single isolate with multidrug resistance. This is compared to the Beef 2007–08 study, in which 16.0 percent of isolates were resistant to tetracycline and 6.5 percent were resistant to streptomycin.

Figure 3. For adult cow isolates in Beef 2007–08 and adult cow and calf isolates in Beef 2017, percentage of *E. coli* isolates[1] that were resistant to the given antimicrobial, by study



[1]The number of isolates equals the number of positive samples since only one *E. coli isolate* was identified in each sample. For Beef 2007–08, one positive sample did not undergo AST.
[2]NA = antimicrobial not tested in the respective study.
[3]Sulfisoxazole replaced Sulfamethoxazole in 2017.

CONCLUSION

E. coli was found on 99.3 percent of the beef cow-calf operations and in 93.3 percent of the samples in the Beef 2017 study. Since *E. coli* is known to be common in the gastrointestinal tracts of humans and animals, the high prevalence was not surprising. For *E. coli* isolates found on beef cow-calf operations, resistance to most antimicrobials was generally low in both the Beef 2017 and Beef 2007–08 studies. There was a moderate amount of resistance to tetracycline in both the Beef 2017 and Beef 2007–08 studies; however, resistance may not be driven by on-farm antimicrobial usage, as use of medically important antimicrobials is low on cow-calf operations (USDA, 2020).

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