Salmonella on U.S. Dairy Operations: Prevalence and Antimicrobial Drug Susceptibility

Background

In 2002, there were 16,580 cases of laboratory-diagnosed foodborne illnesses attributed to 10 organisms under surveillance by the Centers for Disease Control and Prevention (CDC). *Salmonella* was the most common bacterial pathogen identified, accounting for 36.4 percent of the cases.[1] In a CDC analysis of the impact of foodborne illnesses, nontyphoidal *Salmonella* accounted for 25.6 percent of hospitalizations and 30.6 percent of deaths due to known foodborne pathogens.[2] *Salmonella* causes fever, abdominal cramping, and diarrhea in humans. Severe cases can result in systemic infections and even death.

Foodborne *Salmonella* infections have been attributable to raw, undercooked, or contaminated poultry and poultry products, eggs, meat and meat products, dairy products, vegetables, and other agriculture sources.[3]

Salmonella organisms can be transmitted from dairy cattle to humans through several routes, including the consumption of contaminated milk and ground beef, and direct contact with infected animals.[4 5 6 7] On-farm management practices can help control the transmission of foodborne pathogens in dairy cattle. Reducing and controlling pathogens within herds may reduce the risk of human exposure, while benefiting the health and productivity of dairy cows.

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Clinical signs of salmonellosis in cattle include fever, diarrhea, anorexia, abortion, and decreased milk production. The effects of infection can range from subclinical to endotoxemia and death.[8] Cows can shed *Salmonella* in their feces during transportation, lactation, and calving—without showing clinical signs typically associated with infection.

Although over 2,000 serotypes of *Salmonella* have been identified, most laboratory-confirmed *Salmonella* infections in cattle are due to a small number of serotypes. Multidrug resistant strains of *Salmonella* Typhimurium have been recognized for years as important cattle and human pathogens. Recently, a drug-resistant form of *Salmonella enterica* Newport (*S.* Newport) has emerged. These multidrug-resistant isolates have caused disease in humans, adult cattle, and in calves, and are of concern to both veterinary and public health officials.

In 2002, the U.S. Department of Agriculture's (USDA) National Animal Health Monitoring System (NAHMS) conducted the Dairy 2002 study, NAHMS' third national study of U.S. Dairy operations. During Dairy 2002, fecal samples were collected via rectal retrieval on approximately five operations in each of the 21 States* participating in the study. On each operation, fecal samples were collected from approximately 40 cows. The testing scheme was estimated to detect disease on operations where the within-herd prevalence was at least six percent. From March 25 through September 25, 2002, 3,709 samples were collected on 97 operations and cultured for *Salmonella*. Each sample was tested for resistance to a panel of 16 antimicrobial drugs.** Resistance break points used by the National Antimicrobial Resistance Monitoring System were used to classify isolates as susceptible, intermediate, or resistant.

Of the fecal samples collected and cultured, 7.3 percent (269) were positive for *Salmonella*. From these 269 positive samples, 294 isolates were recovered. There were 28 different serotypes identified, of which 62.9 percent of isolates were represented by five serotypes (table 1). *S.* Newport isolates were only 2.7 percent of the isolates recovered and were present on 5.2 percent of operations.

*California, Colorado, Florida, Idaho, Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, New Mexico, New York, Ohio, Pennsylvania, Tennessee, Texas, Vermont, Virginia, Washington, Wisconsin

**amikacin (Am), amoxicillin/clavulanic acid (Amo), ampicillin (Amp), cefoxitin (Cefo), ceftiofur (Ceft), Ceftriaxone (Ceftri), cephalothin (Ceph), chloramphenicol (Chlor), ciprofloxacin (Cip), gentamicin (Gen), kanamycin (Kan), naladixic acid (Nal), streptomycin (Str), sulfamethoxazole (Sulf), tetracycline (Tet), and trimethoprim/sulfamethoxazole (Tris).

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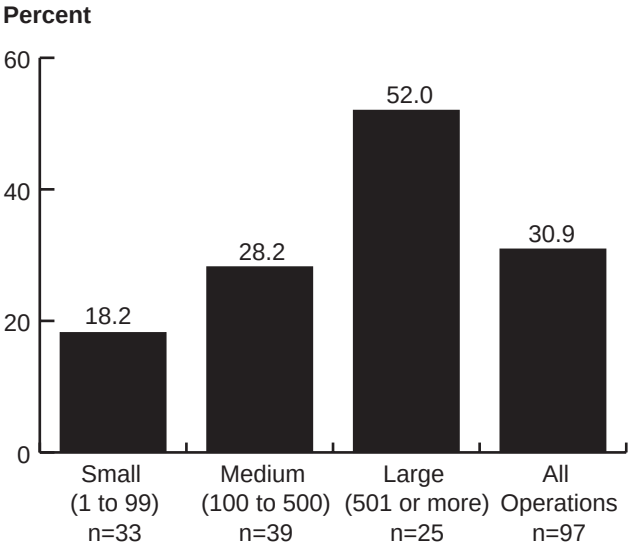
Table 1. Percentage of Isolates and Percentage of Herds for the Five Most Common *Salmonella* Serotypes Isolated from Cattle Feces Collected During Dairy 2002

Salmonella Serotype	Percent Isolates	Percent Herds
Meleagridis	24.1	5.2
Montevideo	11.9	8.3
Typhimurium	9.9	3.1
Kentucky	9.5	8.2
Agona	7.5	3.1

Overall, 30.9 percent of herds had at least one positive culture for *Salmonella.* This herd prevalence is slightly higher—although not statistically significant—than the prevalence reported in NAHMS Dairy '96 study where 27.5 percent of U.S. dairy operations had at least one milk cow shedding *Salmonella* spp.[9]

There was a significant association between herd size and the percentage of herds positive for *Salmonella*. Large operations (501 or more cows) had the highest percentage of herds positive for *Salmonella* (52.0 percent) compared to medium (100 to 500 cows) and small (1 to 99 cows) operations, 28.2 percent and 18.2 percent, respectively (figure 1).

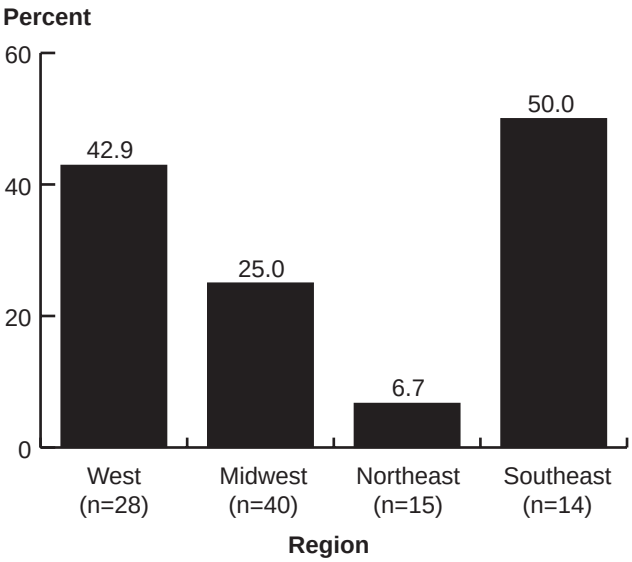
Figure 1. Percentage of Herds Positive for *Salmonella,* by Herd Size



There also was a significant association between region and the percentage of herds positive for *Salmonella*. The percentage of herds positive for *Salmonella* was higher in the Southeast and West regions (50.0 percent and 42.9 percent, respectively) compared to the Midwest and Northeast regions (25.0 and 6.7 percent, respectively) (figure 2).

No association was found between reported cases of diarrhea within herds and *Salmonella*-positive fecal cultures. Of the operations with positive fecal cultures, 26.7 percent reported no cases of diarrhea in any dairy cow, suggesting that cattle in these herds had subclinical infections. There was no apparent relationship between *Salmonella* infections within herds and milk production, as evaluated by rolling herd averages of pounds of milk produced. However, two of the three *Salmonella*-positive operations that had a rolling herd average of less than 16,000 pounds had the highest within-herd prevalence levels of *Salmonella* (97.5 percent and 82.1 percent).

Figure 2. Percentage of Herds Positive for *Salmonella,* by Region



Antimicrobial Susceptibility

Salmonella isolates showed relatively little resistance to a number of antimicrobial agents, with 83.0 percent susceptible to all antimicrobial drugs tested. All isolates were susceptible to amikacin, ciprofloxacin, naladixic acid, and trimethoprim/sulfamethoxazole. Overall, 17.0 percent of the isolates were resistant to at least one antimicrobial drug, and 4.8 percent were resistant to more than one antimicrobial drug. Resistance to tetracycline was most common (11.9 percent of all isolates) followed by resistance to streptomycin (9.6 percent). Table 2 depicts the resistance patterns from all isolates.

Table 2. Resistance Patterns Among *Salmonella* Isolates From Dairy Operations

	Salmonella Isolates	
Resistance Pattern	**Number**	**Percent**
Susceptible to all antimicrobials*	244	83.0
Tet	21	7.1
Str	15	5.1
Amo, Amp, Cefo, Ceft, Ceph, Chlor, Str, Sulf, Tet	7	2.4
Amo, Ampicillin, Cefo, Ceft, Ceph, Chlor, Gen, Kan, Str, Sulf, Tet	2	0.7
Amo, Amp, Cefo, Ceft, Ceph, Chlor, Str, Tet	2	0.7
Amo, Amp, Ceft, Ceph, Chlor, Str, Sulf, Tet	2	0.7
Amo, Ceph, Tet	1	0.3
Total	294	100.0

*Intermediate isolates were classified as susceptible

Multidrug resistance was observed among certain serotypes, including *S.* Mbandaka, *S*. Newport, *S*. Reading and *S*. Typhimurium. Of isolates resistant to more than one antimicrobial drug, 50.0 percent were *S*. Newport. These isolates were found in four different herds. Currently, there is concern in the United States about the emergence of a strain of multidrug resistant *S.* Newport and the potential impact on human health.[10 11] The multidrug resistant form of *S.* Newport was relatively uncommon, accounting for only 2.4 percent of isolates. Table 3 depicts serotypes with at least one resistant isolate and the resistance patterns for those isolates. Again, it is apparent that for some serotypes most isolates are pan-susceptible, whereas for other serotypes most isolates are resistant to some antimicrobials. This appears to be especially true for *S.* Newport.

Table 3. Serotypes of Resistant *Salmonella* Strains and resistance Patterns from Cattle Feces

Serotype	Number Isolates	Percent Serotype Isolates	Resistance Pattern	Number Herds
Agona	22	9.1	Str	1
Anatum	6	33.3	Tet	1
Kentucky	28	53.6	Tet	2
Mbandaka	12	8.3	Amo, Ceph, Tet	1
Monte-video	35	34.3	Str	1
		8.6	Tet	1
Newport	8	12.5	Amo, Amp, Cefo, Ceft, Ceph, Chlor, Str, Tet	2
		62.5	Amo, Amp, Cefo, Ceft, Ceph, Chlor, Str, Sulf, Tet	3
		12.5	Amo, Amp, Cefo, Ceft, Ceph, Chlor, Gen, Kan, Str, Sulf, Tet	1
Reading	1	100.0	Amo, Amp, Cefo, Ceft, Ceph, Chlor, Gen, Kan, Str, Sulf, Tet	1
Typhi-murium	29	3.4	Amo, Amp, Cefo, Ceft, Ceph, Chlor, Str, Tet	1
		6.9	Amo, Amp, Ceft, Ceph, Chlor, Str, Sulf, Tet	2
		6.9	Amo, Amp, Cefo, Ceft, Ceph, Chlor, Str, Sulf, Tet	2
Un-typeable	14	7.1	Str	1
		7.1	Tet	1

Conclusions

The prevalence of *Salmonella* on dairy operations in the United States continues to remain relatively low with 7.3 percent of cows and 30.9 percent of herds having one or more positive fecal cultures. Little change has occurred in *Salmonella* prevalence compared to a similar study conducted in 1996.[9] Resistance of *Salmonella* to antimicrobial drugs on dairy operations in the United States also continues to be relatively low.

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