E. coli O157 and *Salmonella* - Status on U.S. Dairy Operations

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Why should dairy producers be concerned about *E. coli* O157 and *Salmonella*?

Food safety and quality are primary concerns for everyone involved in food production, processing, and preparation - all along the path from farm to consumer. All segments of the food industry are impacted by consumer purchasing decisions, and product safety and quality influence consumer confidence and therefore, consumer demand. Everyone involved shares responsibility, and by working together, we can provide consumers with increasingly safer and higher quality foods.

Within the U.S. cattle industries, several programs that contribute to the high reputation of U.S. meat and dairy products have been ongoing for many years. These programs include: 1) eradication efforts directed towards food-borne pathogens from domestic animal populations (including *Brucella abortus* and *Mycobacterium bovis* from cattle), 2) a quality milk program (including dairy herd inspections and pasteurization as the critical control step), and 3) a meat inspection system based on removal of diseased animals from the human food chain.

Currently, justification is increasing for renewed food safety and quality efforts industry-wide, particularly those focused on microbial pathogens. U.S. medical and productivity costs of bacterial human food-borne illness have been estimated at 2.9 to 6.7 billion dollars each year (Buzby and others, 1996). Pathogens at the top of the list are:

- *Salmonella* species ($0.6-3.5 billion)
- *Staphylococcus aureus* ($1.2 billion)
- *Campylobacter* species ($0.6-1.0 billion)
- *Escherichia coli* O157 ($0.2-0.6 billion)

NAHMS Dairy '96

Widespread and rapid news of human food-borne disease outbreaks increase public concerns, especially with recognition that public health risks can be linked to food products from healthy animals (e.g., recovery of *E. coli* O157 and *Salmonella* from the feces of healthy cattle). Additionally, adoption of world trade agreements (e.g., General Agreement on Tariffs and Trade [GATT]) are expanding trade, and U.S. food production and processing industries are focusing on expanding their world food market share.

To compete, U.S. industries must convince consumers in the U.S. and abroad of our food products' high quality and safety. How are we meeting this challenge? State and federal animal health agencies are cooperating to complete current eradication programs for brucellosis and tuberculosis. To prevent chemical residues in milk and dairy products, the U.S. Pasteurized Milk Ordinance requires extensive testing of milk supplies for antibiotics, and a Milk and Dairy Beef Quality Assurance Program has been developed and implemented by dairy producers. Additionally, the USDA-Food Safety and Inspection Service (FSIS) has implemented the Pathogen Reduction and Hazard Analysis and Critical Control Points (HACCP) system, a process to identify, monitor, and control food hazards in meat processing plants.

The dairy production industry also has a role in pathogen reduction. Though there are multiple sources of microbial contamination of cattle and foods off the farm, reducing the pathogen burden on the farm could lessen the pathogen burden throughout the rest of the food chain. How can these pathogens be reduced on the farm? The interactions between pathogens, cattle, and the environment are not well understood currently, but research completed to date suggests herd management can play a role. As the role of management to pathogen interactions becomes understood, adoption of key management practices could provide significant reduction in pathogen shedding. Understanding this, and recognizing their role in the human food chain, dairy industry leaders are laying groundwork for an expanded herd quality assurance program using management practices shown effective for reducing pathogens. This quality assurance program can benefit consumers and producers by reducing risks from contaminated food products. It may also benefit producers by ensuring domestic and global future market access and may even improve cattle health in the process.

About *E. coli* O157 and *Salmonella*

E. coli O157 and *Salmonella* are bacterial pathogens currently receiving extensive media coverage due to public health concerns. They have been recovered from various types of foods and environmental and water sources. The bacteria live in the intestinal tracts of various animal species, including cattle, that therefore represent a major reservoir for human food-borne disease pathogens. *Salmonella* can also cause disease in animals.

Humans become infected primarily through fecal contamination of food products or water. Another source of human infection, primarily limited to farm families, is contact with ill animals. Lactating dairy cows pose a minimal public health risk through milk and dairy products because of pasteurization, though higher risks are associated with farm families and others drinking unpasteurized milk. Another source of human exposure to these bacteria is culled dairy cows, through meat contamination during slaughter.

Why is *E coli* O157 important?

E. coli O157 has been recognized as an important food-borne pathogen since the 1980's, notable because it can cause hemolytic uremic syndrome as well as bloody or nonbloody diarrhea. In 1993, deaths of four children and widespread media coverage due to an outbreak of human disease caused by *E. coli* O157 in the western U.S. led to an outpouring of consumer demands for safer foods. In response, education campaigns were begun to enlighten consumers about their role in food safety, research projects were initiated to better understand the ecology and epidemiology of this and other bacteria, and new regulations were developed regarding the slaughter/processing inspection process.

How common is *E. coli* O157 on U.S. dairy operations?

As part of the USDA's National Animal Health Monitoring System (NAHMS) Dairy '96 Study, fecal samples from dairy cows across 19 states were collected and sent to the USDA's National Veterinary Services Laboratories for testing. The laboratory tested samples from 91 dairy operations (over 3,600 milk cows and 600 cows to be culled within the subsequent 7 days) and 97 cull dairy cow markets (over 2,200 cull dairy cows). Results showed that, while prevalence of fecal shedding of verotoxogenic *E. coli* O157 in dairy cows at a single sampling was low (0.9% of milk cows and 2.8% of milk cows to be culled within the subsequent 7 days, Figure 1), prevalence across operations was higher. At this one-time sampling, 24.2% of operations and 30.9% of markets had at least one culture-positive cow (Figure 2).

These results are similar to those from previous, more regionalized studies of dairy cattle and those of the 1995 NAHMS Cattle on Feed Evaluation. That study found 1.1% of fecal samples and 63% of 100 feedlots culture positive for verotoxigenic *E. coli* O157 (USDA-APHIS-VS, 1995a). A study with repeated fecal sampling suggested that nearly all dairy operations will be positive for *E. coli* O157 if sampled often enough (Hancock and others, 1997).

Figure 1

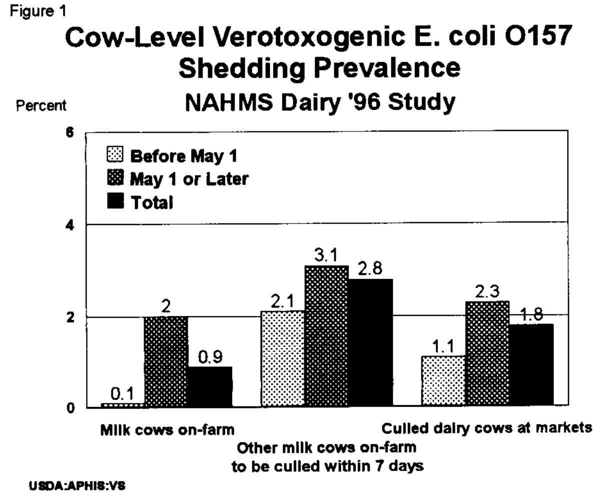
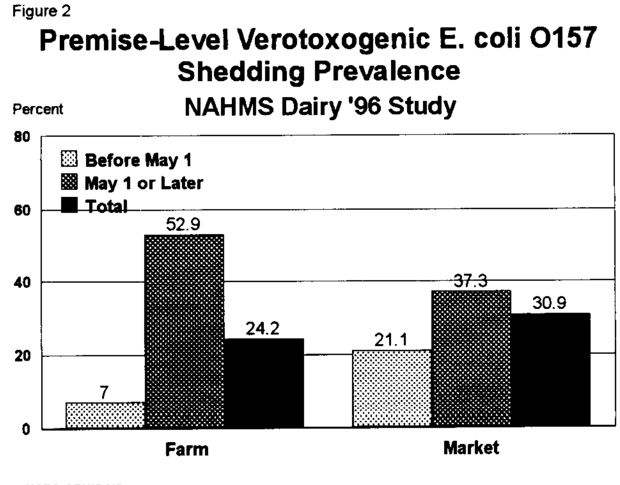


Figure 2



In the NAHMS Dairy '96 Study, fecal samples were collected over a 6-month period from February through July 1996. A clear seasonal pattern of *E. coli* O157 shedding was noted. Over half of the herds tested on or after May 1 were culture positive, compared to very few herds sampled before May 1. Additionally, milk cows, other cows to be culled within 7 days, and culled cows at markets sampled on or after May 1 were more likely to be culture positive than those sampled before May 1. These results are consistent with other studies of cattle shedding and parallel the trend in reported human *E. coli* O157 disease (Griffin and Tauxe, 1991).

The Dairy '96 Study focused on culled dairy cows to compare fecal shedding of cows going to slaughter with the general population of milk cows. Once estimates were adjusted for season and other factors, there were no significant differences in fecal shedding of *E. coli* O157 between milk cows intended for culling within the next 7 days and other milk cows. Fecal shedding of *E. coli* O157 was higher in larger-sized herds (39.1% of herds with 100 or more milk cows compared to 8.9% of herds with fewer milk cows), though season may have confounded this relationship.

How can we reduce fecal shedding of *E. coli* O157?

Due to the epidemiology of this organism, *E. coli* O157 does not appear to be eradicable using test and cull methods that have been successful for pathogens causing persistent cattle infection, such as those causing bovine tuberculosis and brucellosis. For on-farm control of pathogens like *E. coli* O157 that have a typically short duration of shedding, it seems likely that the most effective controls will be identification and removal of sources of new infections. Once understood, this process, including use of key preventive management practices, could be part of a herd quality assurance program. In addition, it is possible that delaying marketing of slaughter cattle, until shedding has ceased in herds undergoing high shedding periods, could reduce contamination of meat products.

From previous studies, risk factors associated with fecal shedding of *E. coli* O157 in dairy cows are unclear. Dietary stress appears to be involved; one clinical trial showed that fasted calves shed the organism longer than nonfasted controls (Cray and others, 1995). Similarly, pens of feedlot cattle that were on feed less than 20 days were more likely to have positive cultures than those pens on feed longer (Dargatz and others, 1997). Another study suggested cow drinking water as a source of *E. coli* O157 (Faith and others, 1996). Factors previously evaluated but not consistently found to be associated with fecal shedding include type of feed ingredient and spread of manure on pasture. Until further research is completed, documented herd management practices to prevent E coli O157 shedding from cattle on farm are not available.

Why is *Salmonella* important?

Salmonella species have been associated with illness among many animals, including humans, and are one of the most commonly reported bacterial causes of human food-borne disease (Bean and Griffin, 1990). Animals shedding *Salmonella* may be a source for food-borne infection of people. Under the new HACCP systems, the USDA-FSIS has identified *Salmonella* as a target organism for monitoring in large slaughter plants beginning in 1998. This monitoring is likely to result in novel cooperative approaches between producers and processors to assure reduction of *Salmonella* shedding in cattle at the time of slaughter.

Over 2,400 different serotypes of *Salmonella* have been identified to date. Differences in distributions and ecology exist, though all can be considered pathogenic at high enough exposure and low enough host resistance. From the NAHMS Dairy '96 Study, the most common *Salmonella* serotypes isolated from dairy cows were *S. montevideo* (21.3% of isolates), *cerro* (13.4%), *kentucky* (8.5%), *menhaden* (7.7%), *anatum* (6.2%), *meleagridis* (6.0%), and *muenster* (4.7%). These serotypes were similar to the most common serotypes shed by feedlot cattle in the 1995 NAHMS Cattle on Feed Evaluation (*S. anatum* 27.9%, *montevideo* 12.9%, *muenster* 11.8%, and *kentucky* 8.2%; USDA-APHIS, 1995b), but differed from the most common isolates from clinically ill cattle (*S. typhimurium* 27.3%, *S. typhimurium copenhagen* 20.3%, *S. dublin* 9.7%, *S. kentucky* 6.2%; Ferris and Thomas, 1995).

One of the phage types of *S. typhimurium* of particular concern to animal and public health agencies currently is definitive type 104 (DT104). A clone of DT104 recently emerged in the United Kingdom in both human and cattle disease outbreaks that has an antimicrobial resistant pattern (R-type) to ampicillin, chloramphenicol, streptomycin, sulfonamides, and tetracycline. DT104 has also been reported in the U.S. in humans, cattle, other farm animals, cats, wildlife, and birds. In the U.S., reports to date indicate lower numbers of DT104 shedding cattle than in the U.K. (Besser and others, 1996).

Salmonella typhimurium was not one of the most common serotypes isolated from dairy cows in the NAHMS Dairy 96 Study (only 2.9% of isolates; results from phage typing of *S. typhimurium* isolates from this study are still pending). However, prevalence of *S. typhimurium* shedding is higher in dairy calves, as evidenced by results from a previous NAHMS study (26.5% of dairy calf *Salmonella* isolates from the 1991-92 NAHMS National Dairy Heifer Evaluation Project were *S. typhimurium*; USDA-APHIS-VS, 1994).

How common is *Salmonella* on U.S. dairy operations?

NAHMS Dairy '96 Study results show that fecal shedding of *Salmonella* in milk cows on farm is similar to that in feedlot cattle (5.4% compared to 5.5% of samples from the NAHMS Cattle on Feed Evaluation [USDA-APHIS-VS, 1995]). Fecal shedding, however, was higher in dairy cows designated for culling within the subsequent 7 days (18.1%) and in culled dairy cows at markets (14.9%, Figure 3). Research is needed to better understand why these dairy cows had higher prevalence of shedding, even before subjected to the stress of transport to markets.

Overall, 27.5% of dairy operations and 66.7% of markets had at least one cow shedding *Salmonella* (Figure 4). This estimate was similar to the 38% of feedlots found culture-positive in the 1995 NAHMS Cattle on Feed Evaluation (USDA-APHIS-VS, 1995b).

These results were based on a one-time sampling which would be expected to differ from results of studies involving repeated sampling. Though only 5.4% of milk cows were positive, percentages of culture-positive dairy operations and cull dairy cow markets indicate cattle are widely exposed to *Salmonella*.

One method to measure exposure to *Salmonella* is through use of antibody tests which indicate previous exposure to the bacteria but not necessarily fecal shedding. In a California study using both culture and antibody tests, 75% of dairy herds showed evidence of recent *Salmonella* exposure with serology (Smith and others, 1994), while only 16% showed evidence based on culture. The authors concluded that a single culture lacks sensitivity, and that the 75% prevalence is likely to be a more accurate prevalence estimate. The herds in this California study were large drylot dairies.

The NAHMS Dairy '96 Study associated *Salmonella* fecal shedding with herd size; 56.5% of the herds with at least 400 milk cows had at least one cow shedding *Salmonella* compared to 38.5% of herds with 100-399 cows and only 4.8% of herds with fewer than 100 cows.

Season of sample collection was related to fecal shedding of *Salmonella,* as it was for *E. coli* O157. Prevalence of *Salmonella* shedding was higher for cows sampled on or after May 1 than for cows sampled before May 1.

How can we reduce fecal shedding of *Salmonella* on-farm?

Research has shown that reduction of *Salmonella* fecal shedding is possible in poultry and swine through modification of management practices. As with *E. coli* O157, an approach for dairy cattle using identification and removal of *Salmonella* infection sources, and adoption of quality assurance programs to assure use of this process, seems more promising than a test and cull approach. *Salmonella* species appear to become established in some environments. They have been shown to be common in outflows from human sewage treatment plants (Kinde and others, 1996) and therefore may contaminate surface water and animals downstream. Animal and plant protein feed sources may also be

Figure 3

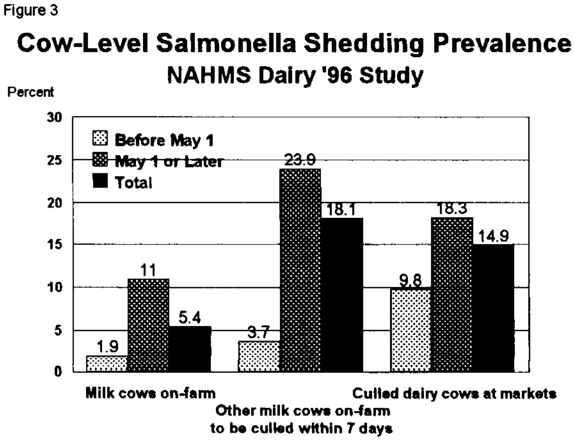
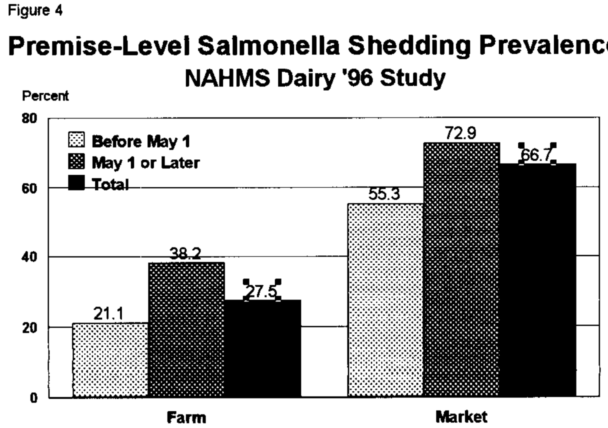


Figure 4



contaminated with *Salmonella* (McChesney and others, 1995; Franco, 1997) and contribute to clinical disease (Anderson and others, 1997). Wild birds (Warnick and others, 1996) and rodents can also be sources of *Salmonella* contamination. These facts complicate development of control strategies since a prevention strategy needs to include all off-farm inputs (cow drinking water, feed sources, sources of water used to irrigate pastures and livestock crops, and other animals and birds) in addition to on-farm control strategies.

If salmonellosis is an animal health problem, on-farm control strategies should be directed toward the *Salmonella* serotypes of concern to the operation. Serotype to serotype epidemiology does differ as some serotypes are more dependent on a cattle host and others on feed or other sources (though persistent shedding of the latter by cattle may occur). For example, removal of long-term carrier (shedding) cattle is most important with serotypes adapted to cattle, namely *Salmonella dublin*. These carriers can best be identified using serology; any animal over 6 months of age is tested twice at a 3-month interval, and animals with persistently high titers to *S. dublin* are culled. In general, these animals can make up 2 to 4% of an infected herd.

Smith and House (1992) have described a number of factors that may be important in *Salmonella* reduction, including presence of carrier cows, source(s) of replacement stock, exposure of fresh cows to sick cow feces, environmental hygiene, use of recycled flush water, contaminated feeds, using contaminated water to irrigate forage crops (especially green chop), infected rodents and birds, and access of rendering trucks to animal areas. McDonough (1995) has also described a salmonellosis control strategy for cattle operations, including sampling points for assessing the source of infection and degree of environmental contamination.

These various factors have been recommended for inclusion in "good management practices" of quality assurance programs, but the relative importance of each, documentation of reduction of *Salmonella* shedding levels associated with full or partial adoption of these practices, and their application to dairy operations still need to be determined. To provide the best science as well as uniformity to this process, the *Salmonella* Committee of the U.S. Animal Health Association is currently working on Best Management Methods for controlling salmonellosis for cattle operations, having already written guidelines for broiler, layer, and turkey operations.

Farm families should consider health risks due to direct or indirect exposure to *Salmonella* from cattle. Hygienic measures, especially around ill cattle or calves, are important. Unpasteurized milk should not be consumed as it contains *Salmonella* (and other human pathogens) on many farms.

Summary

While much information is available about *E. coli* O157 and *Salmonella*, a great deal of research is needed before pathogen reduction practices can be implemented on dairy operations on a broad scale. Data from the NAHMS Dairy '96 Study and others are being analyzed to evaluate associations between shedding of *E. coli* O157 and *Salmonella* and identify effective control measures. Once identified, these measures will form a basis for further research efforts focused at reduction of shedding and persistence in cattle.

Food safety and quality are primary concerns for everyone involved in food production, processing, and preparation. The dairy production industry has a role in implementing management practices demonstrated through time to reduce shedding of fecal pathogens. Reducing the pathogen burden on the farm should lessen the pathogen burden throughout the rest of the food chain, and so, reduce risk of food-borne illnesses for consumers.

Additional information sources

- Your local veterinarian.
- The USDA Food Safety Inspection Service's web page at http://www.usda.gov/agency/fsis/imphaccp.htm.
- Prevent an outbreak of *Salmonella*. Roenfeldt S. 1997. Dairy Herd Management, March:52-56.
- Best Management Practice Methods for controlling salmonellosis and farm family health on dairy farms, available from Cornell University Extension.
- Prospects for *Salmonella* control in cattle. Smith BP and House J. 1992. Proceedings from 25th American Association of Bovine Practitioners Annual Meeting, Sept 1992, 67-72.
- Salmonellosis: Diagnostic approach to disease control and epidemiology in the bovine animal. McDonough PL. 1995. Proceedings from 28th American Association of Bovine Practitioners Annual Meeting, Sept 1995, 61-68.
- *Salmonella* current concepts. House JK and Smith BP. 1997. Proceedings from 30th American Association of Bovine Practitioners Annual Meeting, Sept 1997, 28-32.
- Institute of Food Science and Technology on the World Wide Web at http://www.easynet.co.uk/ifst/hottop1.htm

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