even for persons planning <2 weeks of travel to high-risk areas. In addition, laboratory workers who deal with *S. typhi* and household contacts of known *S. typhi* carriers should be vaccinated. Because the protective efficacy of vaccine can be overcome by the high inocula that are commonly encountered in food-borne exposures, immunization is an adjunct and not a substitute for the avoidance of high-risk foods and beverages. Immunization is not recommended for adults residing in typhoid-endemic areas or for the management of persons who may have been exposed in a common-source outbreak.

Enteric fever is a notifiable disease in the United States. Individual health departments have their own guidelines for allowing ill or colonized food handlers or health care workers to return to their jobs. The reporting system enables public health departments to identify potential source patients and to treat chronic carriers in order to prevent further outbreaks. In addition, because 1–4% of patients with *S. typhi* infection become chronic carriers, it is important to monitor patients (especially child-care providers and food handlers) for chronic carriage and to treat this condition if indicated.

NONTYPHOIDAL SALMONELLOSIS

EPIDEMIOLOGY

In the United States, NTS causes ~12 million illnesses annually, and the incidence has remained relatively unchanged during the past two decades. In 2011, the incidence of NTS infection in this country was 16.5/100,000 persons—the highest rate among the 10 food-borne enteric pathogens under active surveillance. Five serotypes accounted for more than half of U.S. infections during the period 1996–2006: *typhimurium* (23%), *enteritidis* (16%), *newport* (10%), *heidelberg* (6%), and *javiana* (5%).

The incidence of nontyphoidal salmonellosis is highest during the rainy season in tropical climates and during the warmer months in temperate climates—a pattern coinciding with the peak in food-borne outbreaks. Rates of morbidity and mortality associated with NTS are highest among the elderly, infants, and immunocompromised individuals, including those with hemoglobinopathies, HIV infection, or infections that cause blockade of the reticuloendothelial system (e.g., bartonellosis, malaria, schistosomiasis, histoplasmosis).

Unlike *S. typhi* and *S. paratyphi*, whose only reservoir is humans, NTS can be acquired from multiple animal reservoirs. Transmission is most commonly associated with food products of animal origin (especially eggs, poultry, undercooked ground meat, and dairy products), fresh produce contaminated with animal waste, and contact with animals or their environments.

S. enteritidis infection associated with chicken eggs emerged as a major cause of food-borne disease during the 1980s and 1990s. *S. enteritidis* infection of the ovaries and upper oviduct tissue of hens results in contamination of egg contents before shell deposition. Infection is spread to egg-laying hens from breeding flocks and through contact with rodents and manure. The percentage of *Salmonella* outbreaks attributed to eggs has declined significantly in the United States, from 33% during 1998–1999 to 15% during 2006–2008. This decrease probably reflects the impact of the coordinated public health response to *S. enteritidis* infection attributed to eggs, including improved on-farm control measures, refrigeration, and education of consumers and food-service workers. Transmission via contaminated eggs can be prevented by cooking eggs until the yolk is solidified and pasteurizing egg products. Despite these control efforts, outbreaks of *S. enteritidis* infection associated with shell eggs continue to occur. In 2010, a national outbreak of *S. enteritidis* infection resulted in more than 1900 reported illnesses and the recall of 500 million eggs.

Centralization of food processing and widespread food distribution have contributed to the increased incidence of NTS in developed countries. Manufactured foods to which recent *Salmonella* outbreaks have been traced include peanut butter; milk products, including infant formula; and various processed foods, including packaged breakfast cereal, salsa, frozen prepared meals, and snack foods. Large outbreaks have also been linked to fresh produce, including alfalfa sprouts, cantaloupe, mangoes, papayas, and tomatoes; these items become contaminated by manure or water at a single site and then are widely distributed.

An estimated 6% of sporadic *Salmonella* infections in the United States are attributed to contact with reptiles or amphibians, especially iguanas, snakes, turtles, and lizards. Reptile-associated *Salmonella* infection more commonly leads to hospitalization and more frequently involves children, including infants, than do other *Salmonella* infections. Other pets, including African hedgehogs, birds, rodents, baby chicks, ducklings, dogs, and cats, are also potential sources of NTS.

Increasing antibiotic resistance in NTS species is a global problem and has been linked to the widespread use of antimicrobial agents in food animals and especially in animal feed. In the early 1990s, *S. typhimurium* definitive phage type 104 (DT104), characterized by resistance to at least five antibiotics (ampicillin, chloramphenicol, streptomycin, sulfonamides, and tetracyclines; R-type ACSSuT), emerged worldwide. In 2010, resistance to at least ACSSuT was reported in 4.3% of NTS isolates, including 18.6% of *S. typhimurium* isolates. Acquisition is associated with exposure to ill farm animals and to various meat products, including uncooked or undercooked ground beef. Although probably no more virulent than susceptible *S. typhimurium* strains, DT104 strains are associated with an increased risk of bloodstream infection and hospitalization. DCS and trimethoprim-resistant DT104 strains are emerging, especially in the United Kingdom.

Because of increased resistance to conventional antibiotics such as ampicillin and TMP-SMX, extended-spectrum cephalosporins and fluoroquinolones have emerged as the agents of choice for the treatment of MDR NTS infections. In 2010, 2.8% of all NTS strains were resistant to ceftriaxone. Most ceftriaxone-resistant isolates were from children <18 years of age, in whom ceftriaxone is the antibiotic of choice for treatment of invasive NTS infection. These strains contained plasmid-encoded AmpC β-lactamases that were probably acquired by horizontal genetic transfer from *Escherichia coli* strains in food-producing animals—an event linked to the widespread use of the veterinary cephalosporin ceftiofur.

Over the last decade, strains of DCS NTS (MIC, 0.125–1 μg/mL) have emerged and have been associated with delayed response and treatment failure. In 2009, 2.4% of NTS isolates in the United States were DCS or resistant to ciprofloxacin. These strains have diverse resistance mechanisms, including single and multiple mutations in the DNA gyrase genes *gyr*A and *gyr*B and plasmid-encoded quinolone resistance determinants that may not be reliably detected by nalidixic acid susceptibility testing. In 2012, the U.S. Clinical Laboratory Standards Institute proposed a lower ciprofloxacin susceptibility breakpoint (≥0.06 μg/mL) for all *Salmonella* species to address this issue. Currently, because commercial test systems do not contain ciprofloxacin concentrations low enough to allow use of these breakpoints, laboratories need to determine the ciprofloxacin MIC by Etest or another alternative method.

CLINICAL MANIFESTATIONS

Gastroenteritis Infection with NTS most often results in gastroenteritis indistinguishable from that caused by other enteric pathogens. Nausea, vomiting, and diarrhea occur 6–48 h after the ingestion of contaminated food or water. Patients often experience abdominal cramping and fever (38–39°C; 100.5–102.2°F). Diarrheal stools are usually loose, nonbloody, and of moderate volume. However, large-volume watery stools, bloody stools, or symptoms of dysentery may occur. Rarely, NTS causes pseudoappendicitis or an illness that mimics inflammatory bowel disease.

Gastroenteritis caused by NTS is usually self-limited. Diarrhea resolves within 3–7 days and fever within 72 h. Stool cultures remain positive for 4–5 weeks after infection and—in rare cases of chronic carriage (<1%)—for >1 year. Antibiotic treatment usually is not recommended and may prolong fecal carriage. Neonates, the elderly, and immunosuppressed patients (e.g., transplant recipients, HIV-infected persons) with NTS gastroenteritis are especially susceptible to dehydration and dissemination and may require hospitalization and antibiotic therapy. Acute NTS gastroenteritis was associated with a threefold increased risk of dyspepsia and irritable bowel syndrome at 1 year in a study from Spain.