Recent Multistate Outbreaks of Human *Salmonella* Infections Acquired from Turtles: A Continuing Public Health Challenge

Julie R. Harris, Karen P. Neil, Casey Barton Behravesh, Mark J. Sotir, and Frederick J. Angulo

Epidemic Intelligence Service, Office of Workforce and Career Development, and Enteric Diseases Epidemiology Branch, Division of Foodborne, Bacterial and Mycotic Diseases, National Center for Zoonotic, Vector-Borne, and Enteric Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

The federal ban in the United States on the sale of turtles with shell lengths <4 inches that was established in 1975 has reduced the number of turtle-associated human *Salmonella* infections during subsequent years, especially among children. Although numerous sporadic turtle-associated *Salmonella* infections in humans have been reported since the ban went into effect, outbreaks were not reported until recently. Since 2006, 3 multistate outbreaks of turtle-associated *Salmonella* infections have been documented in the United States. This review examines the history of turtle-associated human *Salmonella* infections in the United States and discusses reasons why an increase in turtle-associated salmonellosis may be occurring and how challenges in enforcement of the ban affect disease control. Additional steps should be considered by the public health community, state governments, and enforcement agencies to prevent turtle-associated *Salmonella* infections in humans.

Each year, *Salmonella* causes an estimated 1.4 million illnesses and 400 deaths in the United States [1]. Although *Salmonella* usually causes a self-limiting gastroenteritis, severe invasive infections may occur, particularly in infants and children <5 years old, immunocompromised persons, and elderly individuals. These infections can lead to meningitis, myocarditis, sepsis, and death [2–6].

Although humans usually become infected with *Salmonella* through ingestion of *Salmonella*-contaminated food, ~6% of *Salmonella* infections overall (11% of infections in persons <21 years old) are acquired from direct or indirect contact with reptiles [7]. Because reptile-associated *Salmonella* often affects the groups most vulnerable to serious infection—infants and young children [8–14]—disease prevention is critical.

Despite an ongoing federal ban in the United States on the sale of turtles with shell lengths <4 inches (small turtles), which was established in 1975 [15], turtles remain a source of human *Salmonella* infections [7–9, 16–20]. Furthermore, turtle ownership is increasing in the United States [21] and might be linked to the apparent recent increase in turtle-associated *Salmonella* infections.

**TURTLE-ASSOCIATED SALMONELLOSID IN HUMANS**

Turtle-associated human salmonellosis was first described in the United States in 1963 [22], although it was reported in Great Britain more than 10 years earlier [23, 24]. Turtles carry *Salmonella* as part of their normal intestinal flora and shed the bacteria in their feces; shedding can be continuous or intermittent and may increase in response to stress [25]. Humans become infected with *Salmonella* through both direct and indirect contact with reptile feces; simply having a reptile in the household has been shown to increase the risk of infection [26].

Some *Salmonella* serotypes, including Paratyphi B var. Java, Litchfield, and Urbana, have been particularly associated with turtles [10], and finding such infections in a patient might suggest turtle exposure. However, other, more common *Salmonella* serotypes, such as Typhimurium and Newport, can also be carried and transmitted by turtles [7–10, 12]; this may be true for virtually any serotype.

Infants and young children have consistently comprised a high proportion of persons with turtle-associated *Salmonella* infections [8, 9, 12–14, 17, 23, 27–30]. Because turtles are slow
moving and are perceived to be gentle pets, they are more likely than other reptiles to be given to infants or young children [11], who in turn handle small turtles more closely than they might handle other reptiles, including kissing the turtles or putting them in their mouths. In addition, turtle terrariums frequently contain a reservoir of water that serves as a site of amplification of Salmonella bacteria [31, 32]; children might play with a turtle in the terrarium and splash the contaminated water, increasing their risk of infection. The difficulty in enforcing children’s good hygiene practices, including adequate handwashing immediately after contact with a reptile, compounds this problem.

During the 1960s and early 1970s, baby turtles—particularly Trachemys scripta elegans, the red-eared slider turtle—gained popularity as household pets in the United States, resulting in increasing numbers of reports of turtle-associated salmonellosis among humans [10, 12, 22, 33]. By 1972, ~1 in 25 households in the United States contained a pet turtle, and an estimated 14% of human Salmonella infections, or 280,000 infections per year, were attributed to turtle exposure [10, 12].

The incidence of turtle-associated Salmonella infections in humans led several local and state governments to enact laws during the early 1970s requiring small turtles to be certified as “Salmonella free” before sale [10]. Although enactments of these laws led to a decline in turtle-associated salmonellosis [10], this reduction in infections followed a decline in overall turtle sales, suggesting that the reduced sales may have been at least partially responsible for the reduced infections. However, because many turtles certified as being “Salmonella free” were tested and found to be colonized with Salmonella, the certification efforts were judged to be largely ineffective [27, 34].

THE 1975 FEDERAL BAN ON TURTLE SALES

In 1975, the Food and Drug Administration (FDA) established a ban prohibiting the sale or distribution of small turtles in the United States, except for bona fide scientific, exhibition, or educational purposes [15]. The export of small turtles from the United States was not restricted by the ban, provided certain labeling requirements were met. The length criterion was specified because turtles were most frequently sold as pets to consumers as ~1-inch hatchlings, and the 4-inch rule was intended to provide a size guideline above which it would become difficult for infants and young children to treat turtles like toys or place them in their mouths [35].

The federal ban remains a critical component in the control of turtle-associated salmonellosis in the United States. In 1980, the ban was estimated to prevent 100,000 Salmonella infections annually in children <10 years old in the United States [10]. Similar legislation limiting turtle importation into Canada and Sweden also led to declines in reptile-associated Salmonella infections in humans in these countries [11, 36]. A repeal of the law in Sweden in 1996 resulted in a tripling of reptile-associated Salmonella infections in the country during the following year [11].

In 2007, federal legislation was proposed to lift the ban on the sale of small turtles in the United States, provided that the seller used “proven methods to effectively treat Salmonella” [37]. The provision did not pass, however, keeping the ban in place.

THE TURTLE FARMING INDUSTRY

Most turtle farms in the United States are located in Louisiana—in 1997, Louisiana turtle farms were reported to supply baby turtles for 85%–90% of the global market [38]. Both turtle rearing and shipping provide opportunities for contamination of turtles with Salmonella. Farm-bred turtles are grown in large outdoor ponds at high densities [39]. High-protein feed for turtles, including compact pellets and sometimes fish pieces [39], are introduced into these ponds as turtle feed, providing an excellent medium in which Salmonella can multiply [33, 39]. Water from the mother’s cloacal bladder (used to pack sand after laying eggs) or from the soil itself can contain Salmonella; this water can penetrate the permeable turtle egg [33, 40] or remain on the outside, infecting the turtle embryo or hatching.

In response to the federal ban, farmers, in conjunction with scientists from academia, began to explore techniques to raise Salmonella-free turtles [41]. One treatment, still used on some turtle farms, involves treating the newly laid egg with dilute bleach to clean the egg surface, followed by placement of the egg in an antibiotic wash in a vacuum chamber, which enables penetration of the antibiotics inside the egg [38]. Studies have shown that this procedure can reduce the Salmonella burden in a particular lot of eggs, but it does not guarantee a Salmonella-free hatching [42–44]. Furthermore, because turtles do not show signs of illness when carrying Salmonella and may only shed the bacteria intermittently [34], many turtles that have been guaranteed to be Salmonella free have later been found to have Salmonella. In addition, treatment of turtle eggs with antibiotics has been shown to lead to the development of antibiotic-resistant Salmonella in the turtle [31, 43, 45].

Even in turtles that are free of Salmonella at the time of hatching, maintaining a Salmonella-free state is unlikely. Salmonella is present in foods that can be fed to turtles and is ubiquitous in the environment. In addition, the process of shipping baby turtles provides an excellent opportunity for cross-contamination because hundreds of turtles are tightly packed into cardboard boxes immediately after their first meal [39]. Thus, a few contaminated turtles in a single shipment might contaminate thousands of other turtles, which could then be shipped to multiple distributors for sale.
Although the federal ban has reduced turtle-associated *Salmonella* infections in humans during the years since it went into effect [10], sporadic cases of turtle-associated *Salmonella* continued to be reported in the literature, both domestically [16–20, 29] and internationally [6, 14, 28, 46–48]. However, multistate outbreaks of turtle-associated human *Salmonella* infections were not reported until recently [8, 9]. Since 2006, 3 multistate outbreaks of turtle-associated *Salmonella* infections have occurred, involving >250 people in total.

In July 2007, the Centers for Disease Control and Prevention (CDC) published a report documenting a multistate outbreak of *Salmonella enterica* serotype Pomona infections from September 2006 through April 2007 in patients in 11 states [8]. Twenty laboratory-confirmed infections were reported. Of the 15 interviewed patients, 12 (80%) reported contact with a turtle during the week before the onset of illness; 9 patients reported having the turtle as a household pet. As is commonly seen with turtle-associated *Salmonella* infections, most patients were young—the median patient age was 3 years. One patient associated with this outbreak, a 3-week-old infant, died of *Salmonella* sepsis, sparking intense press coverage.

From October 2007 through January 2008, the CDC and 34 states investigated a multistate outbreak of infections with *Salmonella* Paratyphi B var. Java (also known as serotype Paratyphi B var. L(+) tartrate (+) that began in May 2007 and continued until January 2008, resulting in 107 laboratory-confirmed infections; the median patient age was 7 years. Overall, 47 (60%) of the 78 patients interviewed reported turtle contact during the week before the onset of illness. Thirty-three percent (25/78) of the patients interviewed were hospitalized. In a case-control study conducted during the outbreak, case patients were nearly 41 times more likely to have had contact with a turtle during the week before their illness than were age- and neighborhood-matched control subjects (95% confidence interval, 6.9 to unbounded). Nearly all (87%) of the turtles to which patients were exposed were <4 inches long, and 34% were purchased from a retail pet store. The outbreak strain of *Salmonella* was isolated from turtles and turtle habitats in 6 patient homes [9].

In October 2008, the CDC and 25 states investigated a multistate outbreak of *Salmonella* serotype Typhimurium infections that occurred from March through October 2008. Of note in this outbreak was the apparent transmission of *Salmonella* to children in 3 day care centers after the infection of 1 child in each center who had acquired *Salmonella* infection after exposure to a pet turtle at home. In total, 135 laboratory-confirmed *Salmonella* infections were reported; 45% of patients were ≤5 years old. Of the 83 patients interviewed, 29 (35%) were hospitalized. In a case-control study, patients were 16.5 times (95% confidence interval, 2.4–723.2) more likely than age- and neighborhood-matched control subjects to have been exposed to a turtle during the week before the onset of illness. Samples of turtle aquarium water from the homes of 3 patients yielded the outbreak strain of *Salmonella*.

In the latter 2 outbreaks, patients or their parents were asked whether they were aware before their illness that reptiles were a recognized source of *Salmonella*. Less than 30% reported knowing that turtles commonly shed *Salmonella*, demonstrating a need for improvement in public education on this topic.

**WHY ARE WE SEEING OUTBREAKS NOW?**

It is unclear why, after years of sporadic cases of turtle-associated *Salmonella* infections, 3 outbreaks have been recently detected. One possible explanation is the relatively recent improvements in bacterial enteric disease surveillance. Since its inception in 1996, PulseNet, the National Molecular Network for Foodborne Disease Surveillance, has permitted the identification of cases that may be epidemiologically linked from geographically diverse areas in the United States by enabling comparisons of pulsed-field gel electrophoresis (PFGE) patterns from bacterial isolates, including *Salmonella*. This in turn has fostered improved communication among epidemiologists around the country as they identify common exposures among patients with PFGE-matched isolates and has led to the identification of more enteric disease outbreaks overall. In addition, the occurrence of a *Salmonella* outbreak attributed to a nonfood source, such as turtles, may make investigators more attuned to that source in subsequent outbreaks.

However, the outbreaks may also be partially attributable to a recent increase in US turtle ownership. The loss of most of the US turtle market in 1975 as a result of the federal ban caused an immediate decline in US turtle production from 15 million to 2 million turtles per year and forced the industry to seek other markets for turtles. Beginning in the 1980s, the US turtle farming industry revived as an overseas demand developed for baby turtles, primarily in China [37]. As the Asian market grew, so did US turtle production, reaching nearly 9 million baby red-eared sliders each year from 1997 to 2003. In recent years, however, China has developed a domestic turtle farming industry, which has caused a steep decline in the demand for US turtles [49, 50]. This might be placing pressure on US turtle farmers to find new markets for their baby turtles. Indeed, the proportion of US households with pet turtles doubled from 0.5% in 1996 to 1.0% in 2006, whereas the proportion of households with snakes (0.2% in 1996 and 0.3% in 2006) and lizards (0.5% in 1996 and 0.6% in 2006) showed minimal increase (Figure 1) [21].

Enforcement of the federal ban is difficult, partially because of the exception in the ban that permits the sale of small turtles
in the United States for the purposes of bona fide research, exhibition, or education. Furthermore, despite the ban small turtles are commonly sold in retail pet stores as well as at flea markets and swap meets, from roadside vendors and street vendors (Figure 2), and even online [8, 9]. Unlike retail vendors, those who sell turtles at flea markets, swap meets, and roadside kiosks or online usually do not have fixed locations, making enforcement of the ban against them more challenging. In June 2008, a Google search identified 14 Web sites selling turtles that were <4 inches long, ranging in price from $2.50 to $10.00 each; of these Web sites, 10 (71%) did not mention the federal ban, and 8 (57%) did not mention Salmonella (CDC, unpublished data). Complicating this issue, competing interests and limited resources may force the FDA to prioritize their enforcement efforts toward other health issues.

However, some successes in enforcement have been noted recently, primarily through collaborative efforts between the FDA and state partners. For example, Illinois convicted 2 men of felony and misdemeanor crimes for the sale of small turtles at reptile shows and swap meets in 2005 (C. Austin, personal communication). In July 2008, the owner of a reptile store in Florida was placed on 2 years' probation, forced to pay a $5000 fine, and made to forfeit 7000 turtles and tortoises after an investigation by the Office of Criminal Investigations at the Miami FDA Field Office because of his role in the sale of ~1000 small turtles to a Florida souvenir shop in March 2008 [51]. In addition, the Florida Fish and Wildlife Commission made it illegal to sell red-eared slider turtles with shell lengths of <4 inches starting in July 2007 or to own a red-eared slider turtle with a shell length of <4 inches starting in July 2008 [52]. States can enact additional regulatory action beyond the federal ban to prohibit the sale of turtles [53–57]; enactment of such laws...
prohibiting turtle sales at the state level might be one way to augment federal-level enforcement.

CONCLUSION

Turtles commonly shed *Salmonella* and are therefore unsafe pets, particularly in households with children. The difficulty in enforcing children’s good hygiene practices, including adequate handwashing, makes prevention of transmission to children challenging. Customers should be better informed about the risks of reptile ownership, particularly turtle ownership. In addition, organizations such as the American Academy of Pediatrics and other organizations that address children’s health and safety issues should consider working with public health partners, such as the CDC, to create educational materials about the links between reptiles and human *Salmonella* infection, especially for parents of young children. Primary schools, for example, might include in their curricula lessons on the dangers of reptile-associated *Salmonella*, and pediatricians could provide literature in their waiting rooms. Finally, although the federal ban on turtle sales remains critical in the prevention of turtle-associated salmonellosis, its effectiveness might be augmented by state regulatory actions. For example, states could require vendors to post signs detailing the specifics of the federal ban and providing information to the public on the health risks to infants and young children—including the risk of death—from reptile-associated salmonellosis. More than a half-century after the first reports of turtle-associated salmonellosis, its effectiveness might be augmented by state regulatory actions. For example, states could require vendors to post signs detailing the specifics of the federal ban and providing information to the public on the health risks to infants and young children—including the risk of death—from reptile-associated salmonellosis. More than a half-century after the first reports of turtle-associated salmonellosis in humans and >3 decades after the implementation of the federal ban on small-turtle sales, the continued occurrence of turtle-associated salmonellosis indicates that existing prevention efforts need to be enhanced with novel approaches to protect the public.

Acknowledgments

We thank the many state and local health departments who contributed to the collection of data presented in this article.

Potential conflicts of interest. All authors: no conflicts.

References