Outbreaks of Salmonellosis From Small Turtles

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OBJECTIVE: Turtle-associated salmonellosis (TAS), especially in children, is a reemerging public health issue. In 1975, sales of small pet turtles (shell length <4 inches) were banned by federal law; following the ban, reductions in pediatric TAS were observed. Since 2006, the number of multistate TAS outbreaks has increased. We describe 8 multistate outbreaks with illness-onset dates occurring in 2011–2013.

METHODS: We conducted epidemiologic, environmental, and traceback investigations. Cases were defined as infection with ≥1 of 10 molecular subtypes of Salmonella Sandiego, Pomona, Poona, Typhimurium, and I 4,[5],12:i:-. Water samples from turtle habitats linked to human illnesses were cultured for Salmonella.

RESULTS: We identified 8 outbreaks totaling 473 cases from 41 states, Washington DC, and Puerto Rico with illness onsets during May 2011–September 2013. The median patient age was 4 years (range: 1 month–94 years); 45% percent were Hispanic; and 28% were hospitalized. In the week preceding illness, 68% (187 of 273) of case-patients reported turtle exposure; among these, 88% (124 of 141) described small turtles. Outbreak strains were isolated from turtle habitats linked to human illnesses in seven outbreaks. Traceback investigations identified 2 Louisiana turtle farms as the source of small turtles linked to 1 outbreak; 1 outbreak strain was isolated from turtle pond water from 1 turtle farm.

CONCLUSIONS: Eight multistate outbreaks associated with small turtles were investigated during 2011–2013. Children <5 years and Hispanics were disproportionately affected. Prevention efforts should focus on patient education targeting families with young children and Hispanics and enactment of state and local regulations to complement federal sales restrictions.

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Dr Walters developed the data collection instruments, coordinated the data collection, conducted the analysis, and drafted and revised the manuscript; Ms Simmons and Dr Anderson reviewed and revised data collection instruments, helped coordinate data collection, and critically reviewed and revised the manuscript; Drs Reporter, Kimura, and Ajileye and Ms Bagby, Ms DeMent, Ms Van Zile, Ms Harrison, Ms Borders, Ms Crocker, Ms Adams-Cameron, and Mr Sme collected data through patient interviews, interpreted epidemiologic data, coordinated environmental sampling, and critically reviewed and revised the manuscript; Ms Matthias, Ms Etheridge, Mr Baker, Ms

WHAT’S KNOWN ON THIS SUBJECT: Children are at high risk of Salmonella infection from exposure to reptiles, including turtles. In 1975, the Food and Drug Administration banned sales of pet turtles <4 inches to help reduce pediatric salmonellosis; however, since 2006, a resurgence of turtle-associated Salmonella outbreaks has occurred.

WHAT THIS STUDY ADDS: During 2011–2013, 8 multistate outbreaks were identified; these involved 473 cases of turtle-associated salmonellosis (TAS). Many case-patients were children <5 years (53%) and Hispanic (45%). TAS is a reemerging pediatric public health issue.


by guest on August 27, 2017
Salmonella enterica causes an estimated 1 million illnesses, 19,000 hospitalizations, and 400 deaths annually in the United States.1 Most infections result in self-limiting gastroenteritis; however, children <5 years, immunocompromised persons, and older persons are at increased risk of developing invasive disease.2–6 Although Salmonella infections are predominantly foodborne, an estimated 11% of infections are caused by animal contact.7 Reptile (eg, snake, turtle) and amphibian (eg frog) exposure accounts for ~6% of Salmonella infections,8 and this attribution is much higher among infants, for whom reptile exposure accounts for an estimated 17% of Salmonella infections.3

Salmonella are normal intestinal flora for turtles and other reptiles and can be shed in the feces of healthy turtles throughout their life span.9 Humans can become infected with Salmonella through direct contact with turtles and turtle habitats (eg, tank water) and through indirect contact by cross-contamination of objects and surfaces. Children are disproportionately affected by turtle-associated salmonellosis (TAS). Turtles are more likely to be given to children than other reptiles because they are perceived as gentle, slow, relatively inexpensive, and easy to maintain. Compared with adults, children are more susceptible to Salmonella infection and are more likely to exhibit hand-to-mouth behaviors that increase the risk of infection.10

From 1970 to 1971, exposure to turtles caused an estimated 280,000 Salmonella infections annually, mostly in young children, and accounted for ~14% of all Salmonella infections.11 Consequently, in 1975 the US Food and Drug Administration (FDA) implemented a federal ban on the sale and distribution of small pet turtles (shell length <4 inches).12 Sales of small turtles for exhibition, educational purposes, or export were exempt from the ban. Some states and local jurisdictions also enacted their own bans, giving them authority to investigate and enforce restrictions on sales of small turtles independently of FDA. The federal ban was initially highly effective and, in combination with state and local legislation, prevented an estimated 100,000 infections annually in children <10 years.13 Although the federal ban remains in place, the popularity of pet turtles has increased in recent years. From 2001 to 2011, the percentage of households owning at least 1 pet turtle nearly doubled, from 0.6% to 1.1%.14 Multiple reports since 2004 suggest exposure to small pet turtles is a persistent source of salmonellosis in young children.15–18

The first reported multistate outbreak of Salmonella infections associated with exposure to small turtles occurred in 2006 and included 4 cases;19 from 2006 to 2011, 4 additional outbreaks with a total of 394 cases were investigated, including 1 outbreak that resulted in the death of a 3.5-week-old infant exposed to a small turtle.16,17,19,20 Here, we describe 8 additional multistate outbreaks of Salmonella infections associated with exposure to small turtles that occurred between May 2011 and September 2013. Our objectives were to describe the epidemiology of TAS, understand turtle husbandry practices among case-patients, and determine the retail sources of turtles linked to human illness.

METHODS

Outbreak Identification and Case Finding

National Salmonella outbreaks are most frequently identified through the following process. Diagnostic laboratories forward clinical and environmental Salmonella isolates to state and local reference laboratories and Centers for Disease Control and Prevention (CDC) for serotyping and molecular fingerprinting by pulsed field-gel electrophoresis (PFGE)21; PFGE patterns are uploaded to a central database. PulseNet, the national molecular subtyping network for foodborne disease surveillance, then identifies groups of infections with the same PFGE patterns.21 When PFGE is insufficient to differentiate outbreak cases from sporadic cases, an additional subtyping technique, multiple-locus variable-number tandem repeat analysis (MLVA), may be used.22 In each outbreak, a subset of clinical isolates is tested for antimicrobial susceptibility. State and local health departments interview case-patients or, in the case of children, a parent or guardian, about potential exposures to identify common sources of infection, including animal contact.23

We used 2 additional methods to identify outbreaks of salmonellosis associated with exposure to small turtles: (1) the CDC requested that health departments report all Salmonella infections associated with turtle exposure, and (2) in instances where non–outbreak strains were cultured from turtles and turtle habitats linked to outbreak-associated illnesses, we queried PulseNet for isolates from human infections that had PFGE patterns indistinguishable from these environmental isolates. When human infections were identified, we used previously collected epidemiologic data to assess whether case-patients had exposures in common and determine whether a previously unrecognized outbreak had been identified.

The 8 outbreaks are numbered in the order in which they were identified and comprise 6 Salmonella serotypes and 10 PFGE patterns (Table 1). Among isolates with the outbreak 7 PFGE pattern, MLVA provided additional resolution for distinguishing outbreak-associated isolates from unrelated isolates.
Outbreaks were defined as including multiple serotypes when there were epidemiologic and environmental sampling links between ≥2 case-patients infected with 2 different serotypes, such as isolation of 2 distinct strains from case-patients who were exposed to a single turtle from which both strains were cultured. Cases were defined as infection with ≥1 of the outbreak strains with illness onset from an outbreak-specific date (Table 1) to September 23, 2013.

**Survey of Case-Patients Owning Turtles**

For case-patients with reported exposure to turtles, state, and local health departments interviewed case-patients or, for pediatric case-patients, a parent or guardian, using a focused questionnaire that queried details about contact with turtles and their environments, turtle husbandry practices, and knowledge of the association between reptiles and *Salmonella*.

**Laboratory and Environmental Investigation**

State and local public health and regulatory agencies collected swab and water samples from turtles and turtle tank water at patient homes and at retail establishments where case-patients reported obtaining turtles. Samples were cultured for *Salmonella*; *Salmonella* isolates were serotyped and characterized by PFGE at state reference laboratories and CDC. Because 1 turtle may carry several strains of *Salmonella*, serotyping and PFGE were performed on multiple bacterial colonies from environmental samples when resources permitted.

**Traceback Investigation**

Investigators from state public health, agriculture, and conservation agencies used information provided by case-patients to trace small turtles from patient households to retail establishments, turtle distributors, and turtle farms.

### Statistical Analysis

Analyses of patient data were conducted by using SAS 9.3 (SAS Institute, Cary, NC). Categorical data were compared by using the χ² test, and continuous data were compared using the Wilcoxon rank-sum test. *P < .05* was considered statistically significant.

### Results

#### Patient Demographic and Clinical Characteristics

From May 20, 2011, to September 23, 2013, the outbreak strains were isolated from 473 case-patients in 41 states, the District of Columbia, and Puerto Rico (Fig 1). Outbreaks varied in size from 7 (outbreak 4) to 124 case-patients (outbreak 1; Table 2). Illness onset dates ranged from May 23, 2011, to September 9, 2013, and the number of illnesses peaked in August 2012 (Fig 2).

Case-patients had a median age of 4 years (range: 5 weeks–94 years; *n* = 462). Children <18 years of age accounted for 74% of case-patients; 55% of case-patients were <5 years; and 23% were <1 year (Fig 3). Fifty-five percent of cases were female. Among case-patients with available information, 85 (45%) of 191 case-patients reported Hispanic ethnicity. Ethnicity varied by outbreak; none of the outbreak 7 case-patients identified as Hispanic, compared with 70% of outbreak 1 case-patients (*P = .0001*). Hispanic case-patients were more likely than non-Hispanic case-patients to be children <18 years (88% vs 74%; *P = .02*).

Among 274 persons for whom hospitalization status was reported, 78 (28%) were hospitalized; the median duration of hospitalization was 3 days (range: 1–24 days, *n* = 23). No deaths were reported.

#### Patient Exposure Histories

We interviewed 273 case-patients about potential *Salmonella* exposures in the week before illness onset; 187 (68%) were exposed to turtles (had direct contact with turtles or turtle habitats or were in the same room with turtle). By outbreak, reported exposure to turtles ranged from 47% (outbreak 2) to 74% (outbreaks 1 and 3). Among turtle-exposed case-patients, the majority reported small turtles (124 of 141; 88%), which

| Table 1 Molecular Subtyping Features of Isolates in Outbreaks of Turtle-Associated Salmonellosis, May 20, 2011, to September 23, 2013 |
|--------------------------|---------------------------------|---------------------------------|---------------------------------|
| Outbreak Number          | Serotype and Strain Designation | Xba I PFGE Patterns             | Earliest Onset Date Allowed by Case Definition\(^a\) | Detected in Previous Outbreaks |
| 1                        | Sandiego Strain A               | JLX01.0053                      | August 1, 2011                   | No                              |
| 2                        | Newport Strain A\(^a\)          | JJPX01.1253                     |                                 |                                 |
| 3                        | Pomona Strain A                | POMX01.0004                     | January 1, 2011                  | Yes                             |
| 4                        | Poona Strain A                 | JX6x01.0104                     | October 15, 2011\(^a\)          | Yes                             |
| 5                        | Sandiego Strain C              | JLX01.0002                      | April 1, 2012                   | No                              |
| 6                        | Sandiego Strain B              | JLX01.0051                      | February 15, 2012                | No                              |
| 7                        | Pomona Strain B                | POMX01.0002                     | May 20, 2011                    | Yes                             |
| 8                        | Poona Strain B                 | JLX6x01.0555                    | April 1, 2012                   | No                              |
| 9                        | Poona Strain A                 | JPX01.1056\(^a\)               | June 1, 2012                    | Yes\(^\d\)                     |
| 10                       | Typhimurium Strain A           | JPXXX01.1048                    | June 15, 2012                   | No                              |

\(^a\) Date period for all case definitions is earliest onset date allowed (fourth column) to September 23, 2013.

\(^b\) Case definition specified that patients infected with *Salmonella* Newport must have epi-link to patient infected with *Salmonella* Sandiego Strain A.

\(^c\) For Poona Strain A.

\(^d\) For Sandiego Strain C.

\(^e\) MLVA pattern 4-6-2-7-23-10-36 based on PulseNet USA nomenclature, which corresponds to the pattern 2-11-5-7-0212 in the European nomenclature.

\(^f\) PFGE only, comparison by MLVA not available.
FIGURE 1
Location and number of case-patients by state of residence, May 20, 2011, to September 23, 2013. n = 473. Maps for each outbreak are shown in Supplemental Figures 6–8.

TABLE 2 Selected Characteristics, Case-Patient Demographics, Clinical Features, and Exposures by Outbreak, May 20, 2011, to September 23, 2013

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number/n (%)</th>
<th>Outbreak 1</th>
<th>Outbreak 2</th>
<th>Outbreak 3</th>
<th>Outbreak 4</th>
<th>Outbreak 5</th>
<th>Outbreak 6</th>
<th>Outbreak 7</th>
<th>Outbreak 8</th>
<th>All outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td></td>
<td>124</td>
<td>23</td>
<td>58</td>
<td>7</td>
<td>120</td>
<td>78</td>
<td>19</td>
<td>44</td>
<td>473</td>
</tr>
<tr>
<td>Number of states</td>
<td></td>
<td>22</td>
<td>14</td>
<td>22</td>
<td>3</td>
<td>29</td>
<td>13</td>
<td>5</td>
<td>13</td>
<td>43</td>
</tr>
<tr>
<td>Age (y)</td>
<td></td>
<td>Median</td>
<td>6</td>
<td>5.5</td>
<td>3.5</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
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<tr>
<td></td>
<td>Range</td>
<td>&lt;1–85</td>
<td>&lt;1–89</td>
<td>&lt;1–84</td>
<td>&lt;1–85</td>
<td>&lt;1–98</td>
<td>&lt;1–83</td>
<td>&lt;1–33</td>
<td>&lt;1–70</td>
<td>&lt;1–94</td>
</tr>
<tr>
<td>Patients &lt;18 y</td>
<td></td>
<td>89/122 (73)</td>
<td>13/22 (59)</td>
<td>41/56 (73)</td>
<td>4/7 (57)</td>
<td>86/119 (72)</td>
<td>58/76 (76)</td>
<td>17/19 (89)</td>
<td>33/41 (80)</td>
<td>341/462 (74)</td>
</tr>
<tr>
<td>Patients &lt;5 y</td>
<td></td>
<td>54/122 (44)</td>
<td>11/22 (50)</td>
<td>32/56 (57)</td>
<td>2/7 (29)</td>
<td>73/119 (61)</td>
<td>43/76 (57)</td>
<td>15/19 (79)</td>
<td>26/41 (65)</td>
<td>256/462 (55)</td>
</tr>
<tr>
<td>Patients &lt;1 y</td>
<td></td>
<td>15/122 (12)</td>
<td>7/22 (32)</td>
<td>11/56 (20)</td>
<td>1/7 (14)</td>
<td>43/119 (36)</td>
<td>16/76 (21)</td>
<td>4/19 (21)</td>
<td>7/41 (17)</td>
<td>104/462 (23)</td>
</tr>
<tr>
<td>Female patients</td>
<td></td>
<td>75/123 (62)</td>
<td>14/23 (61)</td>
<td>35/56 (63)</td>
<td>4/7 (57)</td>
<td>62/118 (53)</td>
<td>34/77 (44)</td>
<td>10/19 (53)</td>
<td>22/41 (54)</td>
<td>257/464 (55)</td>
</tr>
<tr>
<td>Hispanic patients</td>
<td></td>
<td>34/48 (71)</td>
<td>6/10 (60)</td>
<td>5/20 (25)</td>
<td>3/6 (50)</td>
<td>19/52 (37)</td>
<td>13/27 (80)</td>
<td>0/7 (0)</td>
<td>5/21 (24)</td>
<td>85/191 (43)</td>
</tr>
<tr>
<td>Hospitalized patients</td>
<td></td>
<td>15/73 (21)</td>
<td>5/18 (28)</td>
<td>15/41 (39)</td>
<td>1/6 (17)</td>
<td>19/69 (26)</td>
<td>6/50 (27)</td>
<td>3/8 (36)</td>
<td>11/29 (38)</td>
<td>76/274 (28)</td>
</tr>
<tr>
<td>Exposed to turtle</td>
<td></td>
<td>51/89 (74)</td>
<td>9/19 (47)</td>
<td>31/42 (74)</td>
<td>4/6 (67)</td>
<td>47/67 (70)</td>
<td>19/53 (58)</td>
<td>9/15 (69)</td>
<td>17/24 (71)</td>
<td>187/273 (68)</td>
</tr>
<tr>
<td>Turtle shell length &lt;4 inches</td>
<td></td>
<td>35/56 (57)</td>
<td>5/5 (100)</td>
<td>21/25 (84)</td>
<td>4/4 (100)</td>
<td>28/34 (82)</td>
<td>14/20 (70)</td>
<td>3/3 (100)</td>
<td>14/14 (100)</td>
<td>124/141 (88)</td>
</tr>
<tr>
<td>Red-eared slider</td>
<td></td>
<td>19/20 (95)</td>
<td>1/1 (100)</td>
<td>10/14 (71)</td>
<td>4/4 (100)</td>
<td>15/19 (79)</td>
<td>8/13 (62)</td>
<td>5/5 (100)</td>
<td>1/3 (33)</td>
<td>64/79 (81)</td>
</tr>
</tbody>
</table>

*a Includes Puerto Rico (Outbreak 2: 1 case) and Washington, DC (Outbreak 5: 2 cases and Outbreak 8: 1 case).
were obtained from untraceable sources (63 of 91; 69%), such as street vendors (34; 37%) and flea markets (13; 14%), or received as gifts (19; 21%). Only 12 (13%) case-patients obtained turtles from pet stores.

Focused questionnaires were completed for 102 case-patients. Exposure to turtles most frequently occurred at home, as reported by 78 (80%) case-patients (Table 3). Direct contact with the turtle or its habitat in the week before illness onset was reported for nearly two-thirds (54 of 88; 61%) of case-patients. Nearly one-third of infants (7 of 22; 32%) and more than half of children <5 years (29 of 56; 52%) had direct contact with turtles.

Cleaning practices showed multiple routes for cross-contamination. Turtle droppings were disposed of in sinks or bathtubs by 46% (33 of 72) of case-patients, and 35% (19 of 54) kept turtles in kitchen sinks, bathroom sinks, or bathtubs during habitat cleaning. One caregiver noted that an infant became infected after baby bottles and the turtle habitat were cleaned in the same sink.

Turtles were owned for a median of 84 days before illness onset (range 1–1278 days, n = 70). Only 14 (15%) of 94 case-patients or, for pediatric case-patients, caregivers of case-patients exposed to turtles were aware of an association between reptiles and Salmonella. Practices and knowledge of the association between Salmonella and turtles did not vary by patient ethnicity (data not shown).

**Laboratory and Environmental Investigation**

Salmonellae with serotypes and PFGE patterns matching patient isolates were cultured from turtles or turtle habitats linked to illness in 7 outbreaks (outbreaks 1–6, 8) and from turtle tanks at retail stores where case-patients in outbreaks 3 and 6 purchased turtles. In 4 outbreaks, turtle tank water samples also yielded outbreak strains other than those of associated clinical isolates (Fig 4, a–d). Additionally, the outbreak 5 strain was isolated during follow-up testing of an outbreak 2 patient exposed to turtles (Fig 4, e).

Together, these laboratory findings create 2 groups of outbreaks where small turtles might originate from a common source: outbreaks 1, 2, 5, and 6 and outbreaks 3 and 4. All isolates were susceptible to a panel of 15 antimicrobial agents.

**Traceback Investigation**

Seventeen case-patients infected with 1 of the outbreak 3 strains described the retail source or location of turtles to which they were exposed; of these, 8 (38%) reported Florida sources, including beach shops (n = 3), souvenir and gift shops (n = 3), pet stores (n = 1), and an unknown vendor (n = 1). Six of the 8 case-patients specifically described purchasing turtles in coastal cities on the Florida panhandle. These turtles were purchased a median of 19 days...
(range: 2–270 days, n = 7) before illness onset; 1 patient did not own turtles but was exposed at a beach shop in the week before illness onset. Water from turtle tanks belonging to 3 outbreak 3 case-patients who reported purchasing small turtles at Florida shops yielded *Salmonella* indistinguishable by PFGE from those isolated from the case-patients.

In August 2012, Florida state regulatory authorities collected turtle tank water and procurement information from 5 Florida shops (Stores A–E) selling small turtles; *Salmonellae* were isolated from samples from all 5 stores. The outbreak 3 strains were isolated from turtle tank water at 4 stores (Stores A–D; Fig 5). Stores A, B, and C received turtles from Louisiana Turtle Farm Y through Broker A, and Stores D and E received turtles from Louisiana Turtle Farm Z through Collector A (M. Walters, personal communication, Florida Fish and Wildlife Conservation Commission). One of the outbreak 3 strains was isolated from turtle breeding pond water collected at Farm Y. Samples collected from ponds at Farm Z and Collector A did not yield *Salmonellae*. The Florida shops voluntarily stopped selling small turtles in August 2012. Laboratory and traceback information was shared with FDA, the federal agency responsible for enforcing the 1975 turtle ban, and the Louisiana Department of Agriculture and Forestry, which issued cease and desist orders to Farms Y and Z, halting their domestic distribution of small turtles.24 In September 2012, the number of cases decreased by >50% from an August 2012 peak and continued to decline in the following months (Supplemental Fig 6C).

**DISCUSSION**

This report documents turtles as an important source of pediatric salmonellosis through identification and investigation of an unprecedented number of multistate *Salmonella* outbreaks associated with exposure to small turtles in a 29-month period. Despite the 1975 federal ban against the sale of small pet turtles, these animals are readily available to a public that is largely unaware of the association between reptiles and *Salmonella*. Turtles from 1 of the 8 outbreaks were traced to 2 Louisiana turtle farms; samples from breeding ponds at 1 of these farms yielded the outbreak strain. To

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**TABLE 3**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number/n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place of turtle exposure</td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>78/97 (80)</td>
</tr>
<tr>
<td>Friend or relative’s home</td>
<td>14/97 (14)</td>
</tr>
<tr>
<td>Retail shop</td>
<td>3/97 (3)</td>
</tr>
<tr>
<td>Outside</td>
<td>1/97 (1)</td>
</tr>
<tr>
<td>Other</td>
<td>1/97 (1)</td>
</tr>
<tr>
<td>Any direct contact with turtle or turtle habitat</td>
<td></td>
</tr>
<tr>
<td>Touched turtle</td>
<td>54/88 (61)</td>
</tr>
<tr>
<td>Contact with turtle habitat</td>
<td>39/52 (75)</td>
</tr>
<tr>
<td>Fed turtle</td>
<td>36/50 (72)</td>
</tr>
<tr>
<td>Kissed turtle</td>
<td>26/49 (53)</td>
</tr>
<tr>
<td>Turtle allowed to roam freely in household</td>
<td>6/40 (15)</td>
</tr>
<tr>
<td>Turtle droppings disposed of in sink or bathtub</td>
<td>14/82 (17)</td>
</tr>
<tr>
<td>Turtle kept in sink or bathtub during habitat cleaning</td>
<td>33/72 (46)</td>
</tr>
<tr>
<td>Knew reptile contact and <em>Salmonella</em> are associated</td>
<td>19/54 (35)</td>
</tr>
<tr>
<td>Small turtle purchased as pet</td>
<td>14/35 (40)</td>
</tr>
<tr>
<td>Small turtle purchased for research, education, or display</td>
<td>35/35 (100)</td>
</tr>
</tbody>
</table>

**FIGURE 4**

Outbreak Connections. Solid arrows indicate that strains from 2 outbreaks were isolated from a single sample. Dashed arrows indicate that environmental samples associated with 1 outbreak yielded serotypes and PFGE matching a different outbreak. Shaded shapes denote 2 clusters of connected outbreaks. aTurtle tank water from the home of an outbreak 1 patient yielded the outbreak 1 and outbreak 2 strains. bTurtle tank water from the home of an outbreak 1 patient yielded the outbreak 5. cTurtle tank water from a pet store where an outbreak 5 patient purchased a turtle yielded the outbreak 6 strain. dTurtle tank water at a Florida souvenir shop where outbreak 3 patients purchased turtles yielded the outbreak 3 and outbreak 4 strains. eFollow-up testing of an outbreak 2 patient exposed to turtles yielded the outbreak 5 strain. fTurtle pond water at Turtle Farm Y yielded the outbreak 2 and outbreak 3 strains.
our knowledge, this is the first time since 1984 that turtles implicated in Salmonella outbreaks have been traced back to the farm of origin, offering a rare opportunity to stop the distribution of turtles causing human illnesses at the source. Traceback for other outbreaks was hindered by the high frequency of purchases from difficult-to-trace vendors, which also pose challenges to turtle ban enforcement and consumer education.

Most case-patients in these outbreaks were infants and children <5 years, consistent with historical observations and recent outbreaks showing that TAS predominantly affects young children. Half of case-patients <5 years had direct contact with turtles in the week before they became ill; others likely became infected in the home through contact with surfaces contaminated by turtles and turtle habitats. Case-patients reported numerous practices that can disperse Salmonella through households, including disposing of turtle droppings in sinks and bathtubs and allowing the turtle to roam freely. The risk of illness from small turtle contact may be affected by poor consumer education. For example, only 15% of case-patients or their caregivers were aware that reptiles carry Salmonella, notably fewer than the 27% reported during a 2008 multistate outbreak associated with turtles.17 Improved consumer education might be a powerful approach for reducing the risk of illness; awareness of the risk of zoonotic disease was protective in an outbreak of Escherichia coli O157:H7 infections linked to a petting zoo.26

Providing consumers with educational materials at the point of sale has been a successful approach for improving consumer knowledge but has limited feasibility for small turtles, which are often sold illicitly through transient sources. Given the large number of infants and young children sickened in these outbreaks, pediatricians and their staff are uniquely positioned to educate families with young children about high-risk pets, including turtles.27 A large proportion of case-patients affected by these outbreaks were Hispanic; however, we did not explore the potential reasons for this observation. Health care providers serving Hispanic communities should be aware of opportunities to provide education about the health risks of pet turtles. Educational brochures and posters that can be used for patient education are available in multiple languages through CDC.28

At Farm Y, Salmonella with molecular fingerprints indistinguishable from the Salmonella Poona Strain A isolated from store and patient turtle tanks linked to outbreak 3 were cultured from breeding pond water. Louisiana turtle farms are licensed by the Louisiana Department of Agriculture and Forestry (LDAF), which requires turtle eggs to undergo a specific treatment process to reduce Salmonella in turtle hatchlings.29 Farm Y reported to the LDAF that turtles shipped to Florida were hatched from treated eggs. Isolation of Salmonella strains with indistinguishable molecular fingerprints from Farm Y breeding ponds, shop and patient turtle tanks, and patient clinical specimens indicates that treating turtle eggs using current protocols might not consistently prevent transmission of Salmonella from pet turtles to people. The source of turtles in the other outbreaks investigated could not be identified because most purchases were from transient, difficult-to-trace vendors. Even if vendors are identified, obtaining compliance with the turtle ban may be challenging. Therefore, some states and local jurisdictions have adopted regulations restricting small pet turtle distribution that enable authorities to promptly stop distribution at points of sale. In outbreak 3, local regulations enabled actions in Florida at the point of sale and in Louisiana at the point of origin, thus halting the domestic distribution of turtles linked with human illnesses.

During this investigation, we augmented traditional molecular surveillance methods with active surveillance for TAS and epidemiologic investigation of all strains isolated from turtle tanks linked to human illnesses. These measures resulted in identification of Outbreaks 5 and 6, which together include 198 cases, 42% of all cases in these outbreaks. These approaches also led to identification of additional outbreak strains in Outbreaks 1 and 3, showing that these outbreaks were larger than...
originally recognized. These findings suggest that traditional surveillance methods alone may underestimate the magnitude of TAS.

A historical review of PulseNet data (Supplemental Figures 9 and 10) and the literature shows that many of the outbreak strains described here were previously associated with TAS. Most notably, the outbreak 2 and 5 strains caused a 2006–2007 outbreak consisting of 20 cases, including an infant who developed sepsis and died after exposure to a small turtle. The outbreak 2 strain was also linked to small turtles purchased from Wisconsin souvenir shops in a 2004 outbreak. Additionally, cases infected with the outbreak 5 strain have been steadily reported since the outbreak began in May 2011, suggesting ongoing transmission of Salmonella from turtles colonized with this strain. When these historic turtle strains are isolated from ill persons, public health authorities should inquire about turtle exposure with case-patients and remain vigilant for a possible turtle-associated outbreak. State and local authorities can choose to follow-up all reports of turtle-associated salmonellosis with the goal of identifying and suspending operations at illegal points of sale for small turtles.

CONCLUSIONS

Despite an ongoing federal ban against their sale as pets, small turtles are a significant source of human illness. Epidemiologic, laboratory, and traceback investigations identified small turtles as the source of 8 Salmonella outbreaks involving 473 confirmed illnesses, mostly in young children. Hispanics accounted for nearly half of all case-patients. In 1 outbreak, small turtles were traced from souvenir shops in Florida to 2 turtle farms in Louisiana. Given the large pediatric population affected, pediatricians and their staff are uniquely well positioned to educate families about steps they can take to reduce the risk of TAS. To reduce the number of illicitly marketed small pet turtles, state and local jurisdictions should consider enacting regulations against the sale of small pet turtles to complement federal enforcement activities.

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ABBREVIATIONS

CDC: Centers for Disease Control and Prevention
FDA: Food and Drug Administration
MLVA: multiple-locus variable-number tandem repeat analysis
PFGE: pulsed field-gel electrophoresis
TAS: turtle-associated salmonellosis

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