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Multistate Outbreak of *Salmonella* Typhimurium Linked to Pet Hedgehogs, United States, 2018–2019

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Summary:

In December 2018, PulseNet, the national laboratory network for enteric disease surveillance, identified an increase in *Salmonella* Typhimurium isolates with an uncommon pulsed-field gel electrophoresis pattern which was previously isolated from hedgehogs. CDC, state, and local health partners interviewed patients with a questionnaire that focused on hedgehog exposures, conducted traceback of patients' hedgehog purchases, and collected fecal and environmental samples. Isolates in this outbreak were analyzed using whole genome sequencing (WGS) and compared to sequence data from historic clinical and hedgehog isolates from a 2011–2013 outbreak of *Salmonella* Typhimurium illnesses linked to pet hedgehogs. Fifty-four illnesses in 23 states were identified between October 2018 and September 2019. Patients ranged from 2 to 95 years, and 67% were female. Eight patients were hospitalized. Eighty-three percent (30/36) of patients interviewed reported owning or having contact with a hedgehog before becoming ill. The outbreak strain was identified in 13 pet hedgehog fecal and bedding samples collected in Michigan, Minnesota, and Oregon. Whole genome sequencing analysis of isolates from this outbreak and the 2011–2013 outbreak fell into 3 distinct grouping that each included closely related clinical and hedgehog isolates. Purchase information available from 19 patients showed hedgehogs were purchased from local pet stores, multiple breeders across 9 states, and through online sales; a single upstream source was not identified. This outbreak highlights the ability of WGS data to link historic and ongoing *Salmonella* illness outbreaks and demonstrates the strain of *Salmonella* linked to hedgehogs might continue to be a health risk to hedgehog owners unless measures are taken to prevent transmission.

Keywords

hedgehogs; *Salmonella* ; whole genome sequencing; outbreak

Background

Every year in the United states, non-typhoidal *Salmonella* causes an estimated 1.35 million illnesses, resulting in 26,500 hospitalizations and 420 deaths (CDC, 2019a). Symptoms of salmonellosis include diarrhea, fever, and abdominal cramps that develop between 6 hours to 6 days after infection. For most people, salmonellosis is self-limiting, and recovery without treatment occurs within 4 to 7 days. However, some people are at increased risk for severe illness, including young children, older adults, and people with weakened immune systems (CDC, 2019d). Most people get infected through eating contaminated food, but animal contact causes an estimated 11% of non-typhoidal *Salmonella* illnesses (Hale et al., 2012). CDC routinely investigates multistate salmonellosis outbreaks associated with pet animals such as live poultry, turtles, guinea pigs, and hedgehogs (Anderson et al., 2017; Basler, Nguyen, Anderson, Hancock, & Behravesh, 2016; Marus, Magee, Manikonda, & Nichols, 2019; Robertson et al., 2018; Walters et al., 2016).

African Pygmy Hedgehogs are popular pets in the United States and other countries. Hedgehogs can carry *Salmonella* without showing signs of illness and shed bacteria in their feces intermittently (Riley & Chomel, 2005). People can then get infected when they come into contact with hedgehogs or their environments. A 1995–1997 outbreak of *Salmonella* Tilene in Canada was linked to pet hedgehogs imported from the United States. The first multistate outbreak linked to pet hedgehogs in the United States was *Salmonella* Typhimurium from 2011–2013 (Anderson et al., 2017; Craig, Styliadis, Woodward, & Werker, 1997)

This report describes a recent multistate outbreak of *Salmonella* linked to pet hedgehogs and the resulting public health outreach efforts and recommendations for hedgehog breeders and owners to reduce the burden of *Salmonella* in the U.S. hedgehog population.

Materials and Methods

In December 2018, PulseNet, the national molecular subtyping network for enteric disease surveillance, identified 9 *Salmonella* Typhimurium isolates with an indistinguishable pulsed-field gel electrophoresis (PFGE) pattern, suggesting that these isolates may have been part of a single outbreak. CDC contacted state public health officials for epidemiologic information and identified hedgehogs as an exposure of interest among patients. A supplemental questionnaire was deployed to collect detailed information about hedgehog exposures, purchase information, pet food, and care practices.

Initially, a case was defined as an infection with *Salmonella* Typhimurium and with an isolate indistinguishable from the outbreak PFGE pattern. The case definition was later modified to also include isolates from October 2018 to September 2019 that were closely related to the outbreak strain by WGS (Besser et al., 2019).

We queried PulseNet for historic clinical and animal isolates that matched the PFGE pattern in the initial case definition. WGS was performed retrospectively on representative isolates from a previous multistate hedgehog outbreak, and on non-outbreak-related human and hedgehog isolates from 2013 to 2018 (Anderson et al., 2017). The United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) National Veterinary Service Laboratories (NVSL) also queried their database for hedgehog isolates. PulseNet analyzed all available isolates with WGS data to assess genetic relatedness by core genome multi-locus sequence typing (Tolar et al., 2019). All sequence data generated by PulseNet was uploaded to NCBI in Bioproject PRJNA230403.

Public health investigators in Michigan, Minnesota, and Oregon collected samples from hedgehogs and hedgehog bedding from patients' homes. The Minnesota Department of Health obtained a list of customers who purchased hedgehogs from a breeder, and customers were provided kits with instructions on how to collect specimens. Completed sampling kits were sent to state health department laboratories for testing.

To determine if there was a single source of hedgehogs illness, CDC, state and local health departments traced pet hedgehogs back from owners, through points of purchase to breeders. State and local health departments contacted hedgehog breeders and pet stores reported by patients during interviews. Breeders were asked about sources for breeding stock, trading practices with other breeders, and general hedgehog husbandry practices.

CDC issued information about the outbreak via the CDC website and CDC social media channels. CDC collaborated with the pet industry and USDA APHIS Animal Care to share information about *Salmonella* and the outbreak with hedgehog breeders. This outbreak was also presented on a webinar in order to provide information directly to hedgehog breeders across the country.

Results

This outbreak included 54 cases from 23 states (Figure 1). Dates of illness onset ranged from October 22, 2018, to August 21, 2019 (Figure 2). Patients ranged in age from 2 to 95 years, with a median age of 18 years. Sixty-seven percent of patients were female. Eight patients were hospitalized, and no deaths were reported.

Of 37 patients that were interviewed, 31 (84%) reported having contact with a hedgehog prior to becoming ill. Patients did not report any other common foods or exposures, suggesting that hedgehogs were the likely source of infection. Patients did not report feeding a common brand or type of pet food to their hedgehogs. No patients reported that their hedgehog had diarrhea or otherwise appeared ill. One patient reported returning their hedgehog to the breeder after owning it for two weeks, although the patient did not provide a reason for the return.

In Minnesota, 10 (71%) of 14 hedgehogs tested positive for the outbreak strain of *Salmonella*. Five were owned by case-patients, and 5 were owned by people identified as hedgehog owners through a customer list provided to the Minnesota Department of Health. Upon interview, the owners of the 5 positive hedgehogs identified by the customer list

did not report any symptoms of *Salmonella* infection. However, one person who initially reported no symptoms became ill shortly after being interviewed. In Oregon, the outbreak strain was also identified in one hedgehog that belonged to a patient. Michigan collected animal and environmental samples from a patient's pet hedgehog, and the outbreak strain was isolated from the hedgehog's bedding.

Of the 54 cases in this outbreak: 40 had isolates with both PFGE and WGS data, 11 were included in the outbreak based exclusively on WGS, and 3 were include based exclusively on PFGE. WGS analysis of retrospective isolates found that 2 clinical isolates from the previous outbreak, 8 NVSL hedgehog isolates, and 6 non-outbreak-associated isolates from 2013–2018 were related to this outbreak strain. Overall, isolates were related within 0–31 alleles by cgMLST (Figure 3).

WGS analysis separated isolates into 3 distinct clades: Clade 1 (0–10 alleles), Clade 2 (0–7 alleles), and Clade 3 (0–12 alleles). Clades 1 and 2 were different by up to 16 alleles, and Clade 3 was different from Clades 1 and 2 by up to 31 alleles. All 3 clades included clinical outbreak isolates and historic NVSL hedgehog isolates. Clade 1 also contained the hedgehog and hedgehog bedding isolates tested during this investigation, and isolates from the 2013 hedgehog outbreak.

Of the 31 patients that reported hedgehog contact prior to becoming ill, 21 were hedgehog owners, and 3 had contact with a friend or family member's hedgehog. Two patients had contact with a hedgehog at a pet store or animal expo. Eighteen patients provided hedgehog purchase information. Of 13 people that provided purchase dates, hedgehogs were purchased between 12 days and 2 years prior to the patient's illness onset. Hedgehogs were purchased from USDA-licensed breeders, unlicensed breeders, pet stores, and through online sales. State and local health departments followed up with 6 hedgehog breeders to find out their sources of breeding stock; two breeders received hedgehogs from a common supplier, and breeders reported anecdotally that sharing and trading breeding stock is a common practice in the industry. No single source was ultimately identified that could account for all hedgehogs purchased by patients (Figure 4).

On January 25, 2019, CDC posted an Investigation Notice to notify pet owners of the outbreak and ways to prevent *Salmonella* transmission from small pets. CDC also disseminated the announcement and prevention messages through social media and news media outreach. The outbreak notice received over 29,000 page views the first week. The notice was updated four times over the course of the investigation, resulting in over 86,000 web page views. *Salmonella* prevention messages focused on handling hedgehogs safely, including discouraging people from snuggling hedgehogs or allowing them to roam freely in the home, and always washing hands after handling hedgehogs or cleaning their habitats (CDC, 2019c).

CDC provided outbreak summaries and prevention information to breeders, veterinarians, and public health officials through targeted outreach via industry groups, webinars, and letters to hedgehog breeders identified in the outbreak (CDC, 2019b). This information encouraged breeders to work with veterinarians to test hedgehogs and use husbandry

practices to reduce the burden and spread of *Salmonella* among hedgehogs and between hedgehogs and customers.

Discussion

This was the second multistate outbreak of illnesses caused by the same *Salmonella* strain linked to pet hedgehogs in the United States reported to CDC. Epidemiologic, laboratory and traceback information suggests this strain of *Salmonella* Typhimurium has been persistent in the U.S. pet hedgehog population and continues to cause illness outbreaks. In response to the 2011-2013 outbreak, CDC recommended that hedgehog owners wash their hands, practice safe handling, clean up properly when handling hedgehogs, and be careful with children and hedgehogs; CDC advised that hedgehog breeders and stores that sell hedgehogs provide public health-related information to owners and potential purchases prior to purchase (CDC, 2013).

Limited regulatory oversight makes it difficult to address *Salmonella* in hedgehog breeding as an issue of public health importance. USDA APHIS has regulatory authority to inspect the premises, veterinary care, records, and husbandry practices for breeders licensed under the Animal Welfare Act (USDA, 2019a). However, this authority only extends to issues pertaining to animal welfare, rather than to issues concerning zoonotic infection and public health. Reaching the entire hedgehog breeding industry might also be hard, as hedgehog breeders with 4 or fewer breeding females are exempt from licensure and inspection and may be difficult to identify (USDA, 2019b).

Despite these challenges, there are ways for public health to respond to this issue to raise awareness and mitigate or prevent future illness. CDC used several communication strategies during this investigation to reach pet owners and hedgehog breeders. CDC maintains a “Healthy Pets, Healthy People” website which provides information on staying healthy around different kinds of pets (CDC, 2018). CDC recommends that people wash hands after touching, feeding, or caring for pets. Hedgehogs and other small mammals, or “pocket pets”, should be kept out of kitchens and other areas where food is prepared, stored, or consumed. They should not be allowed to roam free in the home, and owners should not kiss or snuggle them. Families with children younger than 5 years old, adults aged 65 and older, and people with weakened immune systems might consider a different pet, as these groups are at greater risk for serious illness from *Salmonella* infection. Hedgehog breeders, pet stores and other retailers that sell hedgehogs can help prevent illness by providing prospective pet owners handouts and information from the CDC website.

Breeders can take additional steps to reduce the burden of *Salmonella* in their breeding stock. To monitor for *Salmonella*, breeders can work with their veterinarian to develop a plan to routinely sample feces and hedgehog environments for *Salmonella*. If positive results are identified, the issue might be addressed through disinfecting, increasing sanitation, or identifying and eliminating possible sources of contamination. Breeders should also be aware that false-negative test results might occur, as *Salmonella* can be shed intermittently by infected animals. To prevent disease transmission, breeders should test hedgehogs prior to introduction into the breeding population to ensure that they are not a *Salmonella* carrier.

Antibiotics are not routinely recommended as a way to eradicate *Salmonella* in hedgehogs because of the potential for antibiotic resistance to develop.

This outbreak highlights the ability of WGS to link historic and ongoing *Salmonella* illness outbreaks. Despite public health recommendations made in response to the 2011–2013 outbreak, this strain of *Salmonella* has been persistent in hedgehogs in the U.S. and may continue to be a health risk to hedgehog owners unless measures are taken to prevent transmission.

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Impacts:

- This is the second multistate investigation of *Salmonella* illness linked to pet hedgehogs; both outbreaks were caused by the same outbreak strain
- A single breeder was not identified as the source of infected hedgehogs in either outbreak, suggesting that this strain of *Salmonella* Typhimurium may be widespread in the U.S. pet hedgehog population
- Hedgehog breeders should be knowledgeable on best husbandry practices to reduce *Salmonella*, consult with a veterinarian to perform testing in their breeding population, and educate new hedgehog owners about risk of *Salmonella* transmission

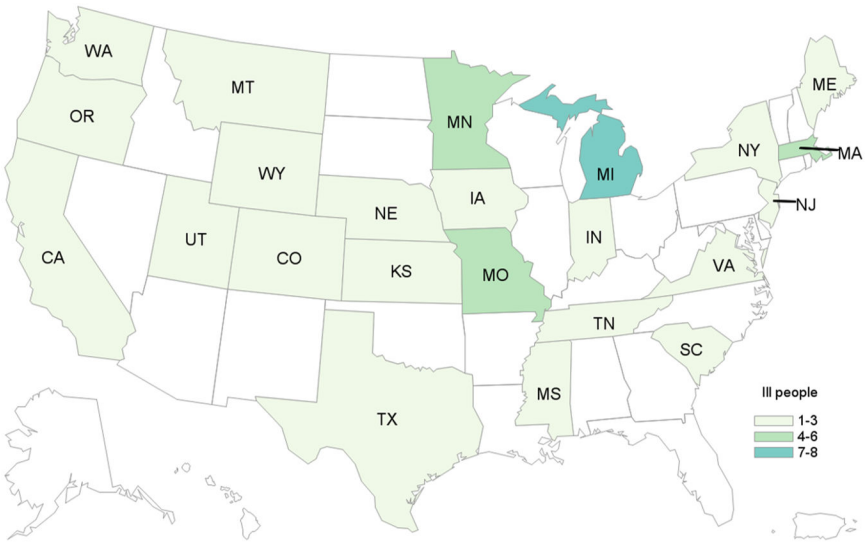

Figure 1.

People infected by the outbreak strain of *Salmonella* Typhimurium linked to pet hedgehogs, by state of residence, 2018–2019

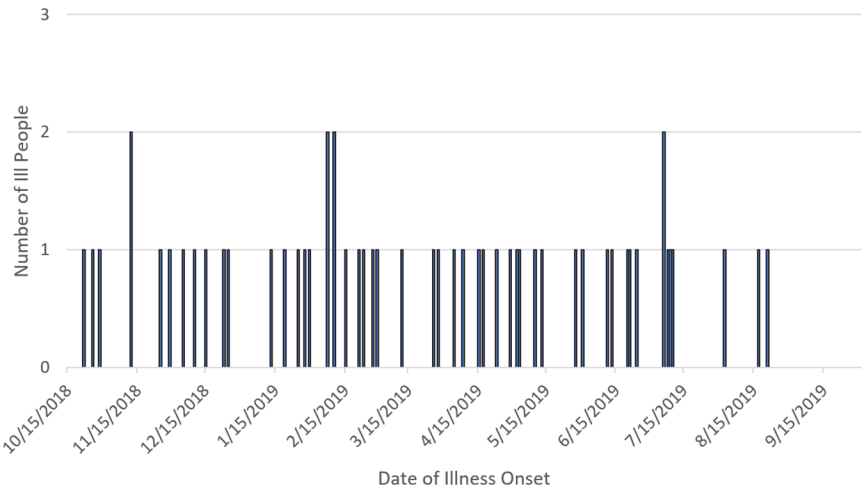

Figure 2.

People infected with the outbreak strain of *Salmonella* Typhimurium, by date of illness onset, 2018–2019. Some illness onset dates have been estimated from other reported information

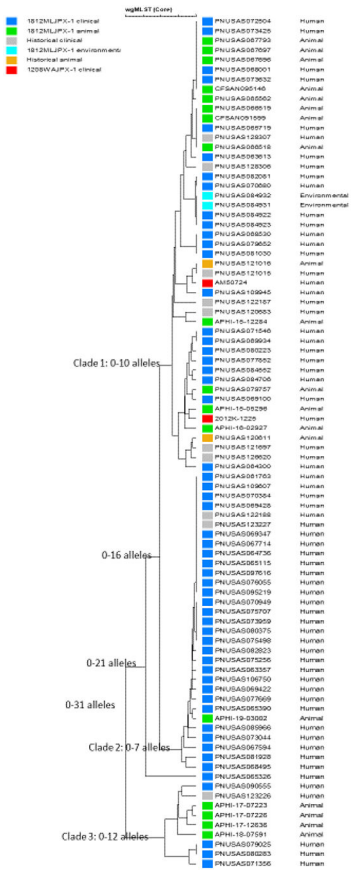

Figure 3.

Phylogenetic tree of *Salmonella* Typhimurium isolates included in the illness outbreak linked to pet hedgehogs, and historic isolates closely related by core genome multi-locus sequence typing. The three main clades described in the results section along with minimum and maximum allele differences are noted. Isolates listed by WGS ID link to biosample and SRA repositories on NCBI.

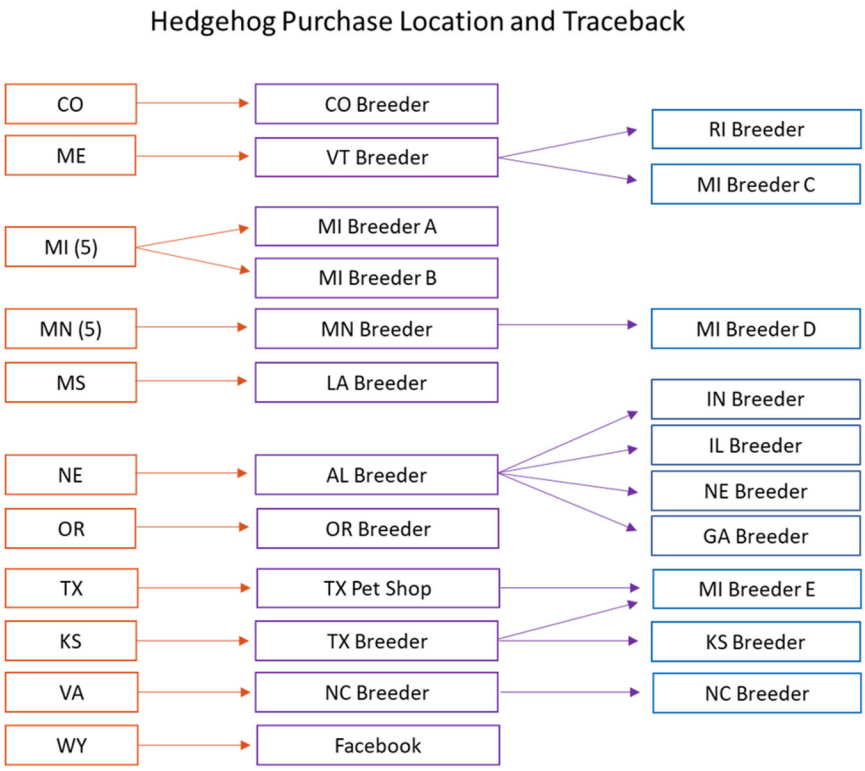

Figure 4.

Diagram illustrating hedgehog purchase locations reported by patients in the *Salmonella* Typhimurium outbreak linked to pet hedgehogs. Purchases were traced back through the point of sale to identify common sources of hedgehog breeding stock; no single source accounted for all illnesses in the outbreak.