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Human Infections with Uncommon *Salmonella* Serotypes Linked to Pet Bearded Dragons, 2012 – 2014

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Abstract

Background: Reptiles are one of the fastest growing sectors in the United States pet industry. Reptile-associated salmonellosis (RAS) continues to be an important public health problem,

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Contributors' Statements:

Dr. Kiebler conceptualized and designed the study, conducted field investigations and sampling, data analysis, drafted the initial manuscript, and approved the final manuscript as submitted.

Ms. Bottichio and Ms. Simmons coordinated and supervised data collection from the state epidemiologists, assisted in drafting and collecting data from the supplemental questionnaire and approved the final manuscript as submitted.

Dr. Klos collected data and identified the initial *Salmonella* Cotham cluster linked to bearded dragon exposure, provided guidance on the supplemental questionnaire design, and approved the final manuscript as submitted.

Drs. Basler, Gurfield, Kimura, Lewis, and Roberts, as well as Ms. Bird and Stiles, assisted with the coordination of state and local public health agencies, field investigation strategy, and sampling at multiple bearded dragon breeder facilities, and approved the final manuscript as submitted.

Drs. Schlater and Lantz coordinated the shipping, processing, and laboratory analysis of samples from bearded dragons in case patient households, bearded dragon breeding facilities, and pet retail stores, both domestically and internationally, and approved the final manuscript as submitted.

Dr. Edling was responsible for providing retail pet store traceback of bearded dragons linked to case patient illness, as well as coordinating the sampling of bearded dragons from retails stores throughout the United States, and approved the final manuscript as submitted.

Dr. Barton Behravesh was the senior epidemiologist for this investigation and provided guidance on study and sampling methodology design, field investigations, traceback analysis, coordination with involved stakeholders, data analysis, and approved the final manuscript as submitted.

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especially among children. We investigated an outbreak of human *Salmonella* infections resulting from serotypes Cotham and Kisarawe, predominately occurring among children.

Methods: An outbreak of illnesses was identified in persons with exposure to pet bearded dragon (BD) lizards. Human and animal health officials, in cooperation with the pet industry, conducted epidemiologic, traceback, and laboratory investigations. Onsite sampling was conducted at two US breeding facilities, one foreign breeding facility, and a large pet retail chain.

Results: A total of 166 patients in 36 states were identified with illness onset dates from 02/2012–06/2014. The median patient age was three years (range <1–79 years), 57% were aged ≤5 years and 37% were aged ≤1 year. Forty-four patients (37%) were hospitalized, predominantly children. Sampling at breeding facilities and a national pet store chain resulted in isolation of outbreak serotypes at each facility; isolation proportions ranged from 2–24% of samples collected at each facility.

Conclusions: Epidemiologic, microbiologic, and traceback evidence linked an outbreak of uncommon *Salmonella* serotypes to contact with pet BDs. The high proportion of infants involved in this outbreak highlights the need to educate owners about the risk of RAS in children and the potential for household contamination by pet reptiles or their habitats. Strategies should be developed to improve breeding practices, biosecurity, and monitoring protocols to reduce *Salmonella* in the pet reptile trade.

Keywords

Salmonella ; zoonoses; reptiles; bearded dragon; outbreak; children; pets

INTRODUCTION

Non-typhoidal *Salmonella* infections cause an estimated 1,000,000 illnesses, 19,000 hospitalizations, and 370 deaths in the United States (US) annually.[1] Approximately 127,000 (11%) *Salmonella* infections have been attributed to animal contact, with 6% of all sporadic infections attributed to reptile-associated salmonellosis (RAS).[2,3] Many RAS cases are reported in children <5 years.[4–6] Although *Salmonella* infections typically cause acute gastroenteritis, severe illness can result, especially in young children, adults >65 years, and immunocompromised persons.[7]

Salmonella are normal flora in the gastrointestinal tract of reptiles, which usually appear healthy while shedding *Salmonella* into their environment.[8] RAS occurs when *Salmonella* are transmitted to humans either through direct contact, indirectly by contact with surfaces contaminated by reptile handlers, or contact with surfaces contaminated by the reptile or its droppings.

Although outbreaks associated with pet iguanas and recurring outbreaks linked to small turtles are well-documented, this report describes the investigation of an outbreak of uncommon *Salmonella* serotypes, Cotham and Kisarawe, linked to pet bearded dragon (BD) lizards and is the most extensive investigation to date of reptile breeders associated with RAS.[5,6,9,10]

PATIENTS AND METHODS

Outbreak Identification and Case Finding

In 2014, the Wisconsin Division of Public Health notified the CDC of human illnesses with an uncommon serotype, *Salmonella* Cotham, associated with exposure to BDs. State and federal investigators and the US Department of Agriculture National Veterinary Services Laboratories (USDA-NVSL) searched historical records for other *Salmonella* serotypes isolated from BDs, ultimately identifying another serotype, *Salmonella* Kisarawe. Subsequently, CDC investigators requested all *Salmonella* Cotham and Kisarawe results from PulseNet, a national molecular subtyping network. A case was defined as illness in a person with a laboratory-confirmed *Salmonella* Cotham or Kisarawe infection from January 1, 2012–June 30, 2014.[11]

Hypothesis generation

State and local health agencies reviewed case-patient data, and re-contacted patients to collect more in-depth exposure information. CDC conducted a search of historic databases to determine the proportion of all Cotham and Kisarawe isolates. Given the potential association between these uncommon serotypes and reptiles, an additional standardized supplemental questionnaire was administered to patients that asked about reptile exposure and husbandry practices with a focus on BDs, purchase information, and *Salmonella* awareness. During interviews, not all respondents answered all questions; therefore, the denominators for respondent response percentages may vary according to the question.

Traceback Investigation

CDC led the traceback investigation in cooperation with local and state human and animal health agencies. BD purchase dates, store locations, and shopper card information were collected with permission from patients and provided to large pet store chains to identify BD suppliers.

Field and Laboratory Investigation

Salmonella Cotham and Kisarawe isolates from state and local public health laboratories were electronically reported to PulseNet.[11] State and local public health and regulatory agencies collected swab and environmental samples from BDs and their habitats in patient households. Onsite sampling was conducted by state, local, and federal investigators at one international and two domestic BD breeding facilities; additionally, one pet store chain voluntarily supplied samples from stores across the US. Environmental samples were collected using commercially acquired sterile pre-moistened skim milk drag swabs, composite fecal samples, composite substrate samples, and sterile cotton swabs moistened and stored in Cary Blair transport media. Direct cloacal swabs of select BDs were collected using sterile cotton swabs moistened and stored in Cary Blair transport media. Egg samples were obtained and tested for both external and internal *Salmonella* contamination. USDA-NVSL cultured pooled lung/liver and intestinal samples obtained from necropsies of BDs that had died of natural causes. They then identified *Salmonella* isolates using MALDI-TOF mass spectrometry, screening isolates for a H antigen common to both Cotham and Kisarawe

serotypes via a Luminex xMAP® *Salmonella* Serotyping Assay. Once *Salmonella* isolates were identified with the H antigen, serotypes Cotham and Kisarawe were fully characterized via classical serotyping.[12]

As a component of field sampling, investigators assessed biosecurity practices at each breeding facility to determine the potential for *Salmonella* cross-contamination within the facility and to identify points of intervention that breeders could use to decrease overall *Salmonella* contamination in their operation.

Statistical Analysis

Analyses of patient, supplemental questionnaire, and specimen data were conducted using R 3.1 (R Foundation for Statistical Computing, Vienna, Austria). Additionally the percentage of cases reporting any reptile exposure was compared to the total number of US households owning a reptile, as reported by the American Pet Products Association National Pet Owners Survey, 2013–2014.[13]

RESULTS

Outbreak Identification and Case Finding

A total of 166 persons infected with the outbreak strains of *Salmonella* Cotham (n=160) or Kisarawe (n=6) were reported from 36 states from February 20, 2012–June 30, 2014 (Figure 1). Patient age ranged from 14 days to 79 years (median=3 years+. Fifty-seven percent (94/166) of ill persons were ≤5 years, and 56% (92/165) were female (Figure 2, Table 1). Among ill persons with available information, 37% (44/118) were hospitalized, and 59% (26/44) of hospitalizations were in children ≤5 years; no deaths were reported (Figure 3). *Salmonella* Cotham and Kisarawe were isolated from patient stool (75%; 125/166), urine (12%; 20/166), blood (8%; 13/166), other body sites (1.2%; 2/166), and unknown (0.6%; 1/166). Of blood isolates, 46% (6/13) were from children ≤5 years. A large proportion of patients were infants (<1 year of age), with 37% (62/166) of illnesses, 36% (16/44) of hospitalizations, and 31% (4/13) of bloodstream infections occurring in infants (Table 2).

Hypothesis generation

Salmonella Cotham was identified in 0.01% (221/1,720,978) of human *Salmonella* isolates reported to CDC since 1964 and 0.001% (5/542,986) of non-human isolates since 1968. Of the five non-human isolates, two were collected from reptiles. *Salmonella* Kisarawe was identified in only 23 human isolates since the first reported occurrence in 1993.

Eighty-four percent (96/114) of patients interviewed reported contact with reptiles before their illness. When asked about the type of reptile, 78% (87/112) of persons reported lizard contact, and 82% (71/87) specifically reported a BD. The percentage of ill persons reporting reptile contact was significantly higher ($P<0.001$) than the percentage of US households (4.2%) reporting reptile ownership.

Forty-eight patients (or patient guardians) in 21 states completed the standardized supplemental questionnaire. Respondent demographics were similar to those observed in the overall outbreak; median age was three years (range <1–75 years), and 56% (27/48)

were female. Fifty-eight percent (28/48) of respondents were ≤5 years, and 55% (26/47) of respondents were hospitalized; median length of stay was two nights (IQR 2–4). Of those hospitalized, 58% (15/26) were ≤5 years, and 31% (8/26) were infants.

Sixty-five percent of ill persons (28/43) reported bloody diarrhea, 68% (19/28) were ≤5 years and 39% (11/28) were <1 year. Fourteen percent (6/43) reported severe illness, such as bloodstream infections, sepsis, and central nervous system infection (Table 2).

Sixty-eight percent (15/22) of respondents were not first-time reptile owners, and all respondents reported owning their current reptile for >6 months; 52% (15/29) of lizard owners had owned their lizard for more than one year. When ill persons were asked about their BD's age at the time of their illness, 54% (15/28) of respondents reported the BD to be more than >2 years old, while 18% (5/28) reported an age between 1–2 years.

Patients or patient guardians in the survey claimed to be well-informed about RAS, with 72% (23/32) saying they were aware of RAS, and 70% (19/27) reporting hand sanitizer was kept near the BD habitat. Twenty-eight percent (8/29) allowed their BDs to roam freely outside of their habitats, and only 3% (1/29) of patients reported their BD exhibiting signs of illness within two weeks of their own illness.

Interviews with patient guardians confirmed that in multiple instances of infant illnesses, the infant had no direct contact with the BD. For instance, parents revealed holding a BD prior to breastfeeding, allowing the BD to roam in the household on the floor where the infant also crawls, and keeping the BD terrarium on the same table used to change the infant's diaper.

Traceback Investigation

The pet industry collaborated closely with CDC to determine the ultimate source of BDs linked to this outbreak. Through this collaboration, multiple BD breeders were identified that may have supplied lizards to numerous pet stores where ill persons obtained their animals. Ultimately, three breeders of interest were identified: Breeder A and Breeder B, with facilities located in the western US, and Breeder C with facilities in Central and South America.

Of 20 patients with BD purchase information, 75% (15/20) reported purchasing BDs from one of two large national pet store chains in 15 different store locations. Pet Store Chain X accounted for 55% (11/20) of total reported purchases, while the second accounted for 20% (4/20). Traceback information obtained from seven of these two pet store locations revealed Breeder A and Breeder C each supplied 4 of the 7 stores where patients purchased BDs.

Initial discussions with Breeder A revealed the facility shifted breeding operations in recent years to smaller-scale production focused on uncommon color variations, instead of large-scale breeding for the pet market. Breeder A also purchased and raised hatchlings produced by Breeder B until they were old enough for distribution to Pet Store Chain X.

Breeder B was a large-scale breeding facility with established biosecurity protocols that bred BDs year-round, selling hatchlings to reptile distributors and other breeders for distribution

to pet stores. At the time of the investigation, Breeder B did not sell directly to any pet stores.

Breeder C, located in Central and South America, was a large-scale, year-round breeding operation that sold directly to pet stores and also to reptile distributors. The owner of the foreign-based breeding locations also owns a US reptile import company, which was used to import BDs into the US. According to US Fish and Wildlife Service data on live reptile imports, Breeder C comprised 69% of all BD imports into the US between March 2009–April 2014.[14]

Field and Laboratory Investigation

Immediately upon notification of the outbreak by CDC, Pet Store Chain X removed all BDs from sale in its stores nationwide in an effort to prevent additional illnesses. Additionally, the Pet Industry Joint Advisory Council (PIJAC), an umbrella trade group representing pet stores and breeders, issued an emergency alert to notify the pet industry of the outbreak. Juvenile BD samples were sent to NVSL from Pet Store Chain X on a regular basis throughout the course of the investigation, resulting in a total of 71 BD samples from pet stores in 32 states. A variety of sample types were collected from each BD breeding facility (Table 3).

A total of 454 samples were obtained from facilities owned by Breeders A, B, and C, as well as Pet Store Chain X, of which 71% (320/454) yielded *Salmonella* (Table 4). Of those sent for *Salmonella* Cotham and Kisarawe serotyping, a total of 11% (46/407) yielded *Salmonella* Cotham and six percent (23/407) yielded *Salmonella* Kisarawe. Of the 69 *Salmonella* Cotham or Kisarawe positive samples, four (6%) yielded both serotypes. As there were more than 50 different Pulsed Field Gel Electrophoresis (PFGE) patterns among isolates from ill persons and the serotypes were uncommon, PFGE was deemed not to be useful in differentiating sub-clusters of related cases in this outbreak.

Salmonella environmental contamination was pervasive at all facilities and was isolated in high proportions, with Breeder A exhibiting 87% *Salmonella* positive, Breeder B 83%, Breeder C 28%, and the pet store 83% (Table 4). Breeder C exhibited the lowest percentage of samples yielding *Salmonella* of all the locations; however, the percentage could be artificially low due to a delay in shipping samples, potentially leading to sample degradation. *Salmonella* Cotham was most commonly found on eggs, in droppings, and in tissue samples, while *Salmonella* Kisarawe was most commonly identified from cloacal swabs and on eggs. *Salmonella* Cotham and Kisarawe were most commonly isolated from the outside of eggs and from juvenile samples (Table 4). *Salmonella* was not isolated from the interior of any eggs at any of the locations sampled.

Onsite investigation of the three breeder facilities revealed there was substantial variability in established biosecurity protocols, site contamination risks, and biosecurity compliance among workers. For example, even though Breeder B exhibited the most stringent biosecurity measures, with published protocols and regular employee training and compliance assessments, *Salmonella* was still isolated in 83% of the samples from this facility. In fact, *Salmonella* Cotham was isolated from the employee refrigerator handle and

Salmonella Kisarawe was isolated from the surface of the employee lunch station at the Breeder B facility.

DISCUSSION

This multistate outbreak of *Salmonella* serotypes Cotham and Kisarawe linked to pet BD exposure is one of the most extensive epidemiologic, laboratory, and traceback investigations into RAS and the pet reptile industry to date. Traceback in the reptile trade can be difficult – animals sold in pet stores can originate from multiple breeders and move through various distributors before their sale to consumers. This complexity within the reptile industry complicated this investigation, which required traceback assistance from pet store chains, in-depth collection and analysis of open source and reptile import/export data, and close collaboration with BD breeders. Through an interdisciplinary One Health approach incorporating human, animal, and environmental health, we were able to combine epidemiologic, laboratory, and traceback information to link human *Salmonella* Cotham and Kisarawe illnesses to BDs sourced from three large breeders.

The popularity of pet reptiles continues to increase; between 2.9–4.2 million US households own a pet reptile.[13,15] More than 700,000 households are estimated to own a pet lizard, with BDs being one of the most popular species. From 2009–2013, BD imports to the US have increased 155%, and exports have increased 142%.[14] BDs are considered docile, tolerant of handling, and easy to maintain, which makes them popular pets for new reptile owners, including children.

Historically, the populations at greater risk of RAS are young children, whose immune systems are still developing and who are more likely to put their hands in their mouths; children are also more likely to experience serious consequences of infection.[7,19] The childhood risk of *Salmonella* infection was apparent throughout this investigation, as larger proportions of patients were children and infants. Infants experienced over one-third of all illnesses, hospitalizations, bloodstream infections, and severe illnesses. Infants would generally not have direct BD contact, which indicates they were likely infected from contaminated household environments or caregivers with contaminated hands or clothing.[5,16–18] Evidence of indirect *Salmonella* transmission to infants was documented in this outbreak, caused by risky practices such as parents holding a BD prior to breastfeeding, allowing the BD to roam in the household on the floor where the infant also crawls, or keeping the reptile terrarium next to an infant's diaper changing area. A high proportion of BD owners in our survey reported knowledge of a connection between reptiles and *Salmonella*; however, it is unclear whether they understood the risk of indirect exposure posed by environmental contamination. Given the docile nature of BDs, owners might handle them more than other reptile species, thereby increasing the likelihood of household contamination.[18]

Physicians and veterinarians can provide direct education to families about reducing the risk of RAS, especially in families with individuals at higher risk of serious illness. CDC recommends not keeping reptiles as pets in homes with children ≤5 years , since young children are less likely to wash their hands after touching a reptile or after contact

with a *Salmonella*-contaminated surface, and are more likely to place their hands in their mouths.[8,19] Additionally, reptiles should not be kept in schools or childcare facilities where children ≤5 years are present.[20,21] Safe reptile handling messages have been created (Box).

In addition to linking *Salmonella* Cotham and Kisarawe illnesses to pet BD exposure, our investigation identified potential critical intervention points and biosecurity measures at breeder locations that show some promise for decreasing the overall burden of *Salmonella*, and specifically serotypes Cotham and Kisarawe, in pet BDs. Since *Salmonella* was not isolated from the interior of eggs, developing protocols to decrease the *Salmonella* load on the exterior of eggs, handling of resulting hatchlings under higher biosecurity protocols, and establishing *Salmonella* Cotham and Kisarawe monitoring programs should be researched as it might reduce environmental cross-contamination of the hatchlings at the breeder level.

Large pet store chains could require their reptile breeders implement such interventions as a prerequisite to purchasing reptiles. They can also improve employee biosecurity training programs and animal husbandry practices to reduce potential cross-contamination among BDs sourced from different breeders, as well as among the different reptile species sold in stores. Pet stores can serve as critical intervention points for reptile owners by educating consumers on the risks of *Salmonella* associated with reptile ownership, practices that will limit exposure of higher risk individuals to reptiles and reduce the risk of household *Salmonella* contamination, and provide advice on choosing an appropriate pet for a particular household.[3] Retail pet stores can also suspend sales of pets linked to active outbreaks and thereby prevent additional human illnesses. These suspensions should be implemented at the time of notification and persist at least until assessments on the source and extent of the outbreak can be identified.

Additionally, much like the National Poultry Improvement Plan (NPIP) acts to protect consumers by monitoring and controlling *Salmonella* serotypes of human health concern in the poultry production chain, the reptile industry could consider strengthening and expanding the National Reptile Improvement Plan (NRIP) to focus on controlling *Salmonella* in its breeding, trade, and retail operations. NRIP is a federal, state, and industry partnership established to identify best management practices and quality assurance programs to reduce the risk of introducing unwanted parasites (e.g. ticks) in and around the US by reptiles. While NRIP is primarily focused on reducing the burden of external parasites, it does have a brief section on reducing RAS risks associated with occupational exposure in the reptile industry and at public events. Therefore, much like NPIP in the poultry industry, NRIP could be leveraged to strengthen requirements on biosecurity, good reptile breeding practices, *Salmonella* reduction protocols, and pathogen surveillance in reptile breeding stock.[22–25]

Currently, no single federal agency has regulatory authority over the entire pet reptile industry (although the US Food and Drug Administration bans the sale and distribution of small turtles).[5,6] Given the lack of regulation, the traceback component of this investigation depended on the willingness of the pet industry to voluntarily work with state and federal human and animal health officials. Through these cooperative relationships and open-source document searches, investigators were able to identify some of the supply chains associated

with pet BD sales from breeder location to point-of-sale. Therefore, this investigation was limited in that not all pet stores and breeders identified in our traceback as sources of BDs participated in onsite sampling and laboratory testing efforts. Additionally, due to laboratory capacity and cost, samples were only screened for the outbreak strains; therefore, the potential breadth of *Salmonella* serotypes present in sampled BD populations were not characterized.

CONCLUSIONS

This investigation linked an outbreak of illnesses from the uncommon *Salmonella* serotypes Cotham and Kisarawe to pet BD exposure that disproportionately affected young children. Since infants are unlikely to have direct reptile exposure, this suggests many infections in this outbreak were likely acquired from indirect exposure through contact with contaminated surfaces, clothing, or other household items. This investigation emphasizes the continued public health problem of salmonellosis among persons exposed to reptiles, and highlights the risk that indirect exposure poses to young children. Pediatricians, veterinarians, and the pet industry should work together to educate families about the risk of *Salmonella* infection from reptiles, reinforce mitigation strategies, and also advise prospective pet owners when particular pets may be inappropriate for higher risk family members, such as young children.

The pet reptile industry should continue to explore critical biosecurity and intervention points in the BD breeding process identified during this investigation to help decrease overall *Salmonella* contamination of BDs intended for the retail pet market.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC.

Abbreviations:

BD	bearded dragon
FDA	Food and Drug Administration
PIJAC	Pet Industry Joint Advisory Council

RAS	reptile-associated salmonellosis
NRIP	National Reptile Improvement Plan
NVSL	National Veterinary Services Laboratories
US	United States
USDA	United States Department of Agriculture
USDA-NVSL	United States Department of Agriculture National Veterinary Services Laboratories

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What's Known on this Subject:

Reptiles are increasingly popular pets even though it is well-known they carry *Salmonella*. Bearded dragons are often marketed toward children, due to their docility, tolerance of handling, and ease of care, placing children at increased risk of *Salmonella* infection.

What this Study Adds:

This investigation is the first identification of human salmonellosis linked to the international bearded dragon trade. Certain large-scale reptile breeding and marketing strategies, as well as species characteristics, could contribute to human *Salmonella* infections, particularly in young children.

Box.

Safe Reptile Handling Recommendations

1. Always wash your hands thoroughly after handling reptiles and amphibians, and anything in the area where they live or roam such as their habitats, food, or equipment.
2. Reptiles and amphibians are not recommended for children under the age of five. This includes in households or school settings. Children younger than 5 years of age, people with weak immune systems, and senior citizens should not handle or touch amphibians or reptiles or their environment because they are at a higher risk for serious illness and hospitalization from *Salmonella* germs.
3. Keep your reptiles and amphibians and their equipment out of your kitchen or anywhere in your home where food is prepared, served, or consumed. Never use food-preparation areas to clean reptile and amphibian habitats or anything in their habitats. These items should be cleaned outside of your home. If you clean the habitat in the bathroom, thoroughly clean and disinfect the area right afterwards.
4. Don’t cross-contaminate! You don’t have to touch a reptile or amphibian to get sick from their germs. Be aware that any reptile food such as frozen or live rodents, equipment, and materials, including the tank water, can be contaminated with *Salmonella* and other germs.
5. Do not kiss or snuggle with reptiles and amphibians because this will increase your risk of getting sick.

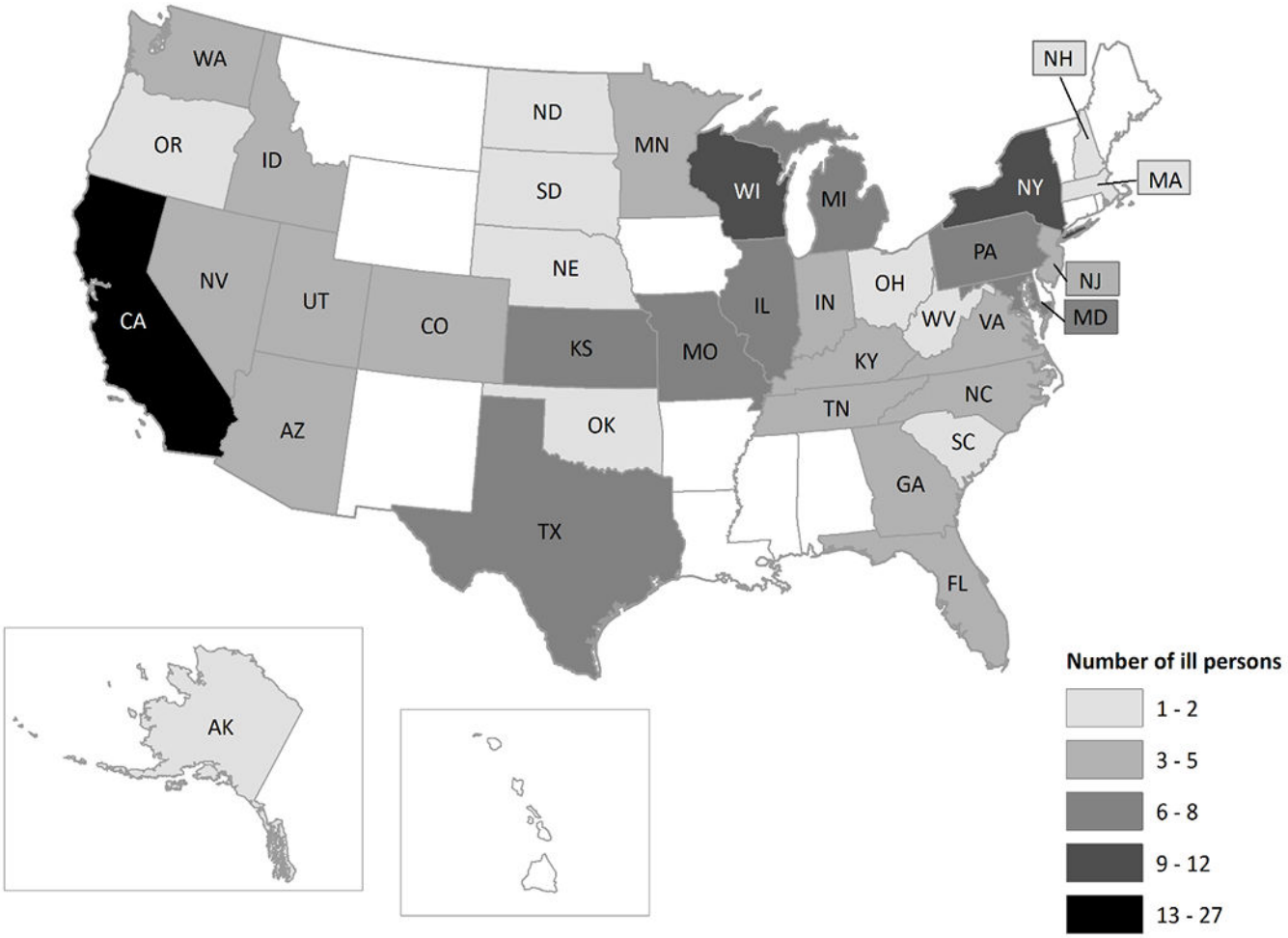

Figure 1.

Location and Number of Patients by State of Residence, January 1, 2012 to June 30, 2014, n=166.

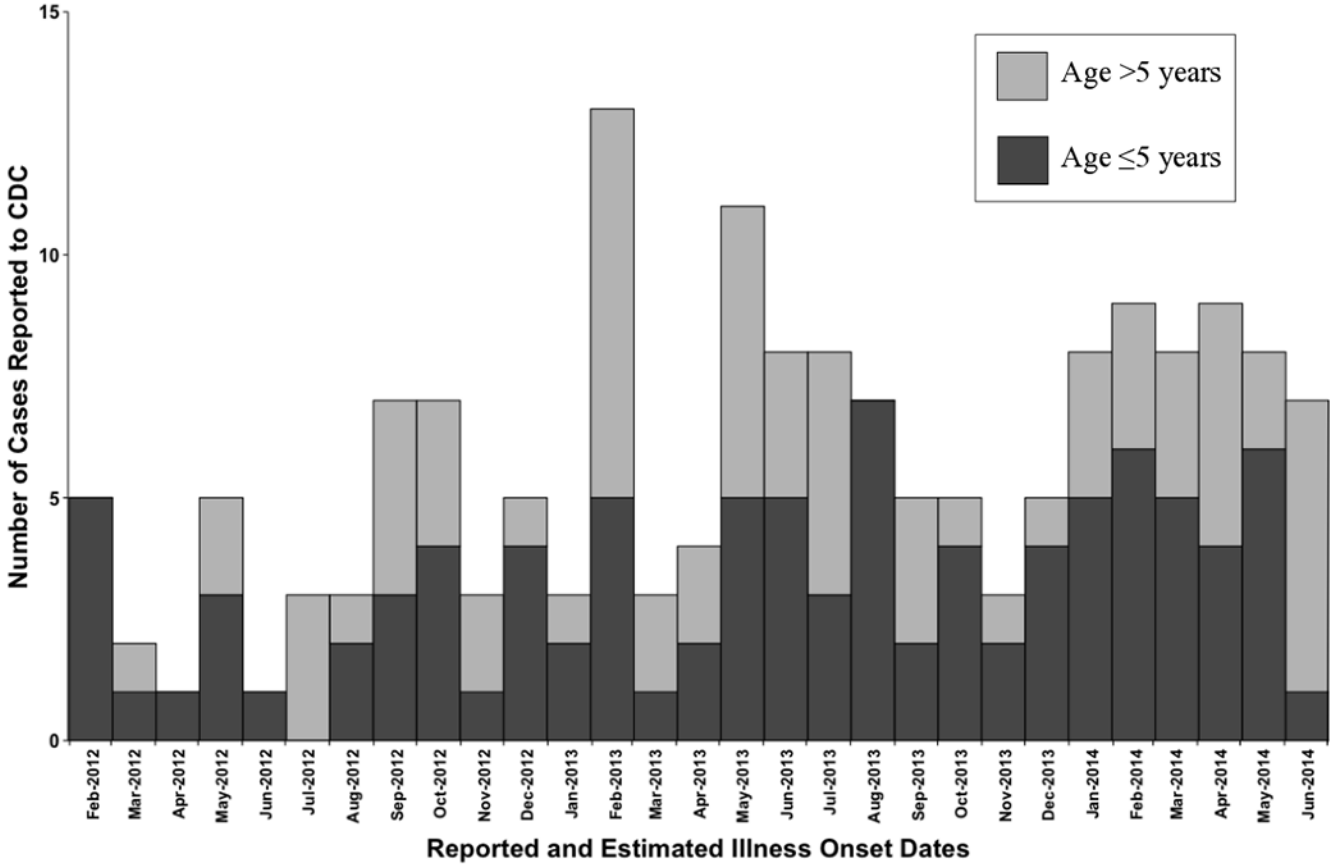

Figure 2.

Number of Patients Infections with *Salmonella* Cotham or Kisarawe by Month of Illness Onset and Age Category, February 20, 2012 to June 30, 2014, n=166.

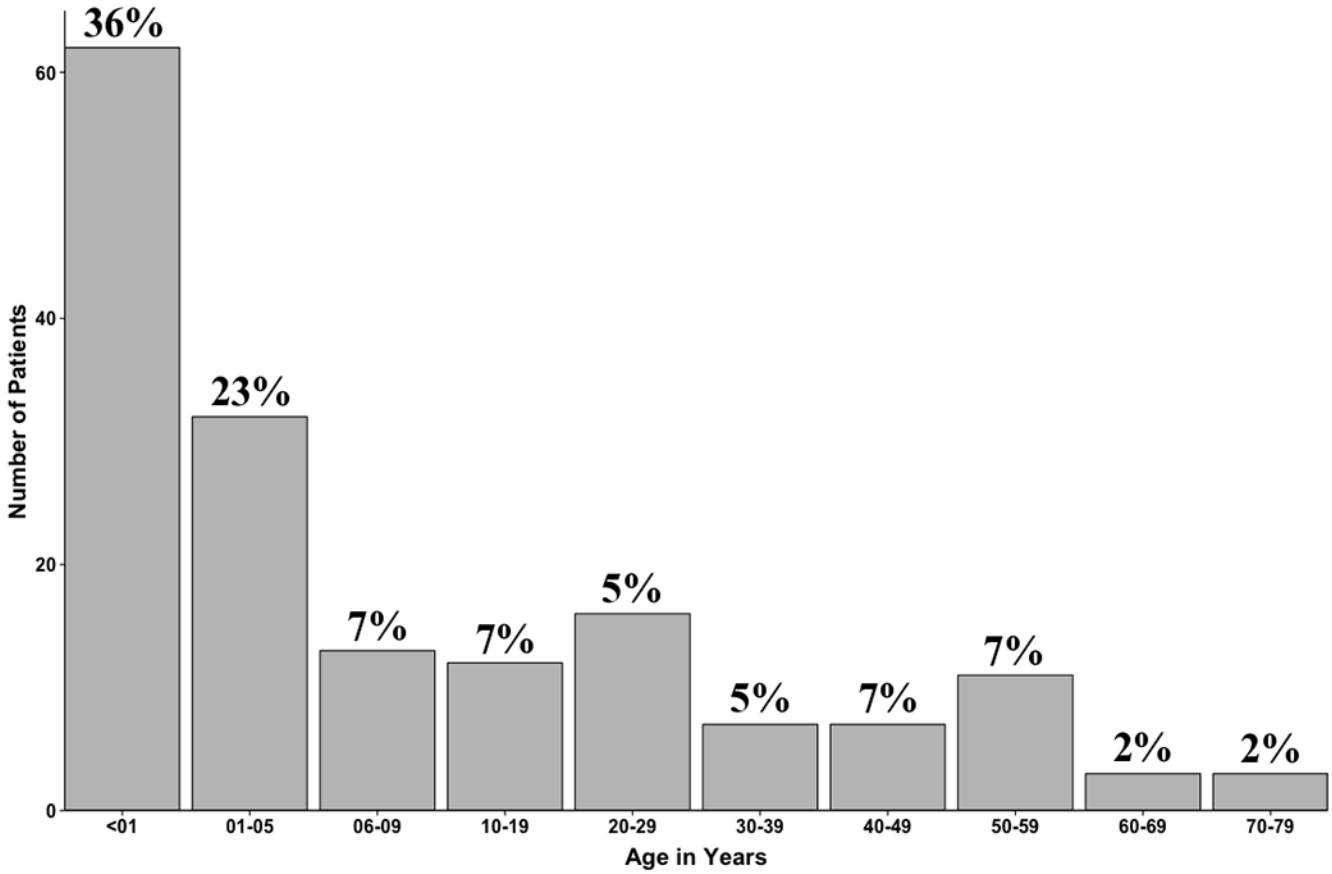

Figure 3.

Number of Patients by Age Group and Hospitalization Status, February 20, 2012 to June 30, 2014, n=166. Of patients with hospitalization information (n=118), the percentage above each bar represents the contribution of each age group to total hospitalizations.* Total hospitalizations were n=44.

* Due to rounding, the total percentage may not equal 100%.

Table 1.

Selected patient demographics, February 20, 2012 to June 30, 2014.[a]

Characteristics	Years	Range
Patient age, median	3	<1–79
	No. (n=166)	**%**
Patient age, ≤5 years	94	57
Patient age, <1 year	62	37
	No. (n=165)	**%**
Female	92	56
	No. (n=118)	**%**
Hospitalizations	44	37
Deaths	0	0

[a]Information was not available for all patients.

Table 2.

Comparison of patient outcomes in children, <1 year of age and 1–5 years of age.

Outcomes	< 1 year of age No. (%)	1–5 years of age No. (%)
Illnesses (n=166)	62 (37)	32 (19)
Hospitalizations (n=44)	16 (36)	10 (23)
Bloodstream infections (n=13)	4 (31)	2 (15)
Severe illnesses[a] (n=6)	2 (33)	1 (16)
Antibiotic use (n=27)	8 (30)	6 (22)

[a]Severe illnesses include self-reported conditions such as bacteremia, sepsis, and central nervous system infection.

Table 3.

Sample types and number collected at each bearded dragon breeding facility.

Sample Type	Breeder A No.	Breeder B No.	Breeder C No.
Bedding	0	6	17
Cloacal swab	4	7	31
Droppings	25	32	14
Egg	5	35	0
Environmental Swab	49	87	31
Feed[a]	3	16	0
Water	3	3	15
Total	89	186	108

[a]Feed could include lettuce, insect larvae, crickets, and mash used to grow the insect larvae.

Table 4.

Results of onsite sampling at bearded dragon breeding facilities and a national pet store chain. Isolation of *Salmonella* spp. and serotypes Cotham and Kisarawe, by sample location, sample type, and bearded dragon age group.

	***Salmonella* spp.**			**Cotham**		**Kisarawe**		
Sample Description	**No. Positive**	**n**	**%**	**No. Positive**	**%**	**No. Positive**	**%**	**n[a]**
Sampling Location [b]								
Total	320	454	71	46	11	23	6	407
Breeder A	77	89	87	14	16	8	9	89
Breeder B	154	186	83	13	9	7	5	139
Breeder C[c]	30	108	28	2	2	2	2	108
Pet Store Chain X	59	71	83	17	24	6	8	71
Sample Type								
Total	320	454	71	46	11	23	6	407
Bedding	19	23	83	1	6	1	6	18
Cloacal swab	12	42	29	0	0	5	12	42
Droppings	59	71	83	13	18	4	6	71
Egg	34	40	85	2	13	3	20	15
Environmental swab	128	167	77	12	7	4	2	167
Feed[d]	5	19	26	0	0	0	0	5
Tissue[e]	59	71	83	17	24	6	8	71
Water	4	21	19	1	6	0	0	18
Age Group [f]								
Total	307	421	73	43	11	23	6	396
Egg[g]	34	40	85	2	13	3	20	15
Hatchling	51	54	94	5	9	2	4	54
Juvenile	99	115	86	26	23	9	8	115
Adult	123	212	58	10	5	9	4	212

[a] Total samples serotyped for *Salmonella* Cotham and *Salmonella* Kisarawe

[b] Samples from pet stores were of tissue from juveniles only.

[c] Number of positive samples could be artificially low due to a delay in sample shipment and potential sample degradation

[d] Feed could include lettuce, insect larvae, crickets, and mash used to grow the insect larvae.

[e] Tissue samples were obtained via necropsy of pet store bearded dragon mortalities.

[f] Not all samples could be characterized by bearded dragon age.

[g] The exterior and interior of eggs were tested. *Salmonella* was not isolated from the interior of any eggs.