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A Comparative Analysis of Salmonellosis among Children Younger than 6 Months and 6-12 Months of Age

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ABSTRACT

A COMPARATIVE ANALYSIS OF SALMONELLOSIS AMONG CHILDREN YOUNGER THAN 6 MONTHS AND 6-12 MONTHS OF AGE

By

GITANGALI BAICHI BAROI

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INTRODUCTION: The Centers for Disease Control and Prevention (CDC) estimates that approximately 1.2 million illnesses and 450 deaths occur annually in the United States from non-typhoidal Salmonella infections (CDC, 2015). Children are most likely to get salmonellosis; the elderly, infants, and those with compromised immune systems are likely to have a severe illness.

PURPOSE OF THE STUDY: In this study, an analysis of childhood salmonellosis comparing infants under 6 months and those 6 to 12 months old was completed. This analysis was conducted in order to compare exposures among the two age groups.

METHODS: Data were downloaded from SENDSS into Microsoft Excel for data cleaning; data management and analysis was conducted using R Statistical Packaging (R-3.2.3), Epi Info™ 7 and Microsoft Excel 2016.

RESULTS: The occurrence of contact with dog was 43.59% among children under than 6 months and for children 6-12 months, the rate of contact with dog was 48.37% (OR=0.82, p =0.33); the incidence of exposure to bird was 1.54% for children under 6 months and among children 6-12 months, the incidence was 2.31% (OR=0.66, p = 0.57). In children under 6 months, the incidence of exposure to pig was 0% and among children 6-12 months, the rate of exposure was 0.46% (OR=0, p = 0.34); among children under 6 months, the occurrence of exposure to reptile/amphibian was 6.63% and between children 6-12 months, the rate of exposure was 3.67% (OR=1.86, p = 0.17). Among children younger than 6 months, the incidence of contact with cat was 11.40% and for children 6-12 months, the rate of exposure was 15.21% (OR=0.72, p = 0.26). The occurrence of contact with others with similar illness among children under 6 months was 18.18% and the incidence of contact with others for children 6-12 months was 23.53% (OR=0.72, p = 0.56); for children under 6 months, the rate of exposure to children in diapers was 44.75% and among children 6-12 months, the incidence was 45.77% (OR=0.96, p = 0.84). For children under 6 months, the incidence of attending large gatherings was 18.84% and between children 6-12 months, the rate of exposure to large gatherings was 22.64% (OR=0.79, p = 0.35). Among children under 6 months, the incidence of exposure to watermelon

was 1.04% and between children 6-12 months, the rate of exposure was 10.95% (OR=0.086, p = <.0001); for children under 6 months, the rate of exposure to chicken was 2.06% and the incidence of contact with chicken among children 6-12 months was 35.85% (OR=0.0389, p = <.0001). The rate of exposure to tomatoes among children under 6 months was 0.52% and the incidence of exposure to tomatoes in children 6-12 months was 3.76% (OR=0.135, p = 0.028); among infants under 6 months, the rate of exposure to dairy was 3.66% and for children 6-12 months, the occurrence of exposure to dairy was 26.29% (OR=0.107, p = <.0001). In children under 6 months, the incidence of exposure to berries was 0.52% and the rate of exposure to berries among children 6-12 months was 13.46% (OR=0.034, p = <.0001); the incidence of exposure to turkey among children under 6 months was 0.52% and in children 6-12 months, it was 12.38% (OR=0.037, p = <.0001). The rate of exposure to beef in children under 6 months was 1.04% and in children 6-12 months, it was 10% (OR=0.094, p = <.0001).

DISCUSSION AND CONCLUSION: There was no significant difference in the incidence of animal exposures for salmonellosis among children under 6 months and 6 to 12 months in Georgia. Moreover, there was no significant difference between environmental exposures among children under 6 months and 6-12 months. Nonetheless, we did find statistically significant difference in food exposures among infants under 6 months and those over 6-12 months. Our finding suggests that when compared to children 6-12 months, infants under 6 months are less likely to have been exposed to food items other than infant formula or breast milk.

A COMPARATIVE ANALYSIS OF SALMONELLOSIS AMONG CHILDREN YOUNGER THAN 6 MONTHS AND 6-12 MONTHS OF AGE

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The highest education is that which does not merely give us information but makes our life in harmony with all existence.

- Rabindranath Tagore

Author's Statement Page

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TABLE OF CONTENTS

List of Tables

List of Figures

INTRODUCTION

I. BACKGROUND

Salmonellosis, transmission and trends

In 1885, *Salmonella* was discovered by Dr. Salmon, a U.S. Veterinary surgeon, who successfully isolated the strain enterica or cholesraesuis from the intestine of a pig (Rao et. al, 2004). It is a rod-shaped, gram-negative, facultative anaerobe in the Enterobacteriaceae family (Rao et. al, 2004). In any given year, approximately 200 of 2449 known *Salmonella* serotypes are detected in the United States (Bandy et al, 2003). *Salmonella* is commonly found in the intestines of people, animals and birds (Mayo Clinic, 2014). The principal habitat of *Salmonella* bacteria is the intestinal tract of humans and animals (Bandy et. al, 2003). Although *Salmonella* cannot grow outside the digestive tracts in large quantities, it can still survive in a wide range of environments if the temperature and humidity are favorable, such as in tropical climates (Williams et al, 2016). Today, *Salmonella* is a major cause of diarrheal diseases worldwide and food and water contamination have been associated as probable transmission sources (Williams et al, 2015).

Salmonella can be found in food products such as raw poultry, eggs, and beef, and occasionally, on unwashed fruits and vegetables (Jones et. al, 2006). Foods that are prepared on surfaces that were in contact with raw meat products previously, can become contaminated with the bacteria (Jones et. al, 2006). Salmonellosis can also occur from handling pets such as snakes,

turtles, and lizards. Before birth, reptiles are infected either as live newborns or shelled embryos when passing through the cloaca of the mother (Bandy et. Al, 2003). During the process of slaughtering, animal feces may get in raw meat and poultry and then can infect humans (Mayo Clinic, 2014). *Salmonella* can be on the outside or the inside of a raw shell egg as hens can be infected with the bacteria and show no signs or symptoms (Mayo Clinic, 2014). Many fresh produce that are imported into the country are hydrated in fields or washed with water contaminated with *Salmonella*. (Mayo Clinic, 2014). Cross contamination may also lead to the illness if the juices from raw meat and poultry come into contact with fresh fruits and vegetables. Many foods become contaminated when prepared by individuals who don't wash their hands properly after using the bathroom or changing a diaper (Mayo Clinic, 2014).

In the general population, *Salmonella* infections can take place in small, contained outbreaks or in large outbreaks in hospitals, restaurants, or institutions for children or the elderly (National Institute of Health, 2015). The Centers for Disease Control and Prevention (CDC) estimates that approximately 1.2 million illnesses and 450 deaths occur annually in the United States from non-typhoidal *Salmonella* infections (CDC, 2015). According to the Foodborne Diseases Active Surveillance Network, or FoodNet, the annual incidence of *Salmonella* in the United States is 15.2 illnesses per 100,000 individuals (CDC, 2015). The World Health Organization (WHO) estimates that every year, there are tens of millions of human cases around the world and more than hundred thousand deaths (WHO, 2015). Salmonellosis is one of the most common foodborne diseases (Jones et. al, 2006). Children younger than 6 months are most likely to become infected with *Salmonella* and the elderly, infants, and those with compromised immune systems are likely to have a severe illness. Among other age groups of the Foodborne Diseases Active Surveillance Network (FoodNet), children under 12 months had the highest

incidence of sporadic salmonellosis with an overall annual incidence rate of 141.6 cases per 100,000 infants (Rowe et. al, 2004). The most common route of transmission for human infection is by oral ingestion and direct contact with the bacteria is not necessary for further transfer of *Salmonella* (Bandy et al, 2003).

Symptoms and Prevention

Most people infected with *Salmonella* develop diarrhea, fever, and abdominal cramps between 12 and 72 hours after infection (CDC, 2015). The illness usually lasts 4 to 7 days, and most individuals recover without ant treatment (CDC, 2015). For some patients, diarrhea can be severe and hospitalization may be required. In these patients, the *Salmonella* infection may spread from the intestines to the blood stream and then to other parts of the body (CDC, 2015). In order to diagnose salmonellosis, a clinical specimen, such as stool or blood, from an infected person is needed to differentiate it from other illnesses that cause diarrhea, fever, and abdominal cramps. After *Salmonella* is identified in the specimen, additional testing can be done to further distinguish the bacterium (CDC, 2015). If *Salmonella* infection has spread to the blood or other tissues, antibiotics are needed (Bandy et. al, 2006). However, there is no vaccine to prevent salmonellosis (Bandy et. al, 2006).

In order to prevent the spread of salmonellosis, it is recommended that food service workers, day care workers and health care workers are excluded from work until diarrhea subsides (Bandy et. al, 2006). Food products of animal origin may be at a higher risk because some animals are known reservoirs for *Salmonella* (Bula-Rudas et. Al, 2015). As a result, people should not eat raw or undercooked eggs, poultry, or meat (Bula-Rudas et. al, 2015). Meat, such as poultry and hamburgers, should be cooked until the minimum internal temperature reaches approximately 165°F and meat is not pink in the middle (Bula-Rudas et. al, 2015). People should

also not consume raw or unpasteurized milk or other dairy products (Bula-Rudas et. al, 2015). Fresh produce should be washed thoroughly and cross-contamination of foods should be prevented. After contact with uncooked foods, hands, cutting boards, counters, knives, and other utensils should be washed thoroughly. Handwashing after handling animals or contact with animal feces is also recommended to prevent salmonellosis.

FoodNet and Salmonellosis

The Foodborne Diseases Active Surveillance Network (FoodNet) was established in July 1995 and is a collaborative program among CDC, 10 state health departments, the U.S. Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS), and the Food and Drug Administration (FDA) (CDC, 2015). State health departments that participate in FoodNet include Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, Tennessee and selected counties in California, Colorado, and New York. FoodNet personnel at each state health department regularly communicate with clinical laboratories in their state to get reports of infections diagnosed among residents of these regions (CDC, 2015). FoodNet conducts surveillance for *Campylobacter*, *Cryptosporidium*, *Cyclospora*, *Listeria*, *Salmonella*, Shiga toxin-producing *Escherichia coli* (STEC) O157, and non-O157, *Shigella*, *Vibrio*, and *Yersinia* infections diagnosed by laboratory testing of samples from patients (CDC, 2015).

Salmonellosis in children

Due to their developing immune systems, young children, when compared to adults, are more inclined to higher incidences of gastrointestinal infections and are at higher risk for complications from these illnesses (Schutze et. al, 1998). In recent investigations of risk factors for infant salmonellosis, it has been suggested that contaminated environmental sources

contribute more to children becoming infected with *Salmonella* than contaminated foods. (Eidelman et. al, 2012). This may be due to the fact that children have a more limited dietary exposure to foodborne pathogens compared to adults and their environmental exposures also differ based on common behaviors such as crawling and putting things and hands in mouth (Eidelman et. Al, 2012). The purpose of this analysis is to describe demographics and exposures among reported cases of salmonellosis under 1 year of age residing in Georgia. A secondary purpose is to compare these characteristics and exposures between children younger than 6 months and those 6-12 months of age.

II. LITERATURE REVIEW

In the United States, foodborne illnesses represent a substantial, yet largely preventable, health burden (CDC, 2015). Accordingly, in the course of the late 1980s and early 1990s, epidemiologists at the Centers for Disease Control and Prevention (CDC) proposed to form a population-based active surveillance system to better measure the rate of enteric infections and their impacts on society with the intention of reducing discrepancies that are inherent in passive national surveillance systems. (Henao et. al, 2015). Therefore, in 1995, with support from Food Safety and Inspection Service (FSIS) of the USDA, CDC established the Foodborne Diseases Active Surveillance Network (FoodNet), an active, population-based sentinel surveillance system (Henao et. al, 2015). FoodNet is primarily responsible for overseeing changes in the occurrence of selected major bacterial and parasitic illnesses that are transmitted commonly by food, points illnesses to its sources and settings, and estimates the total numbers of foodborne illnesses in the United States (Henao et. al, 2015). Today, FoodNet conducts population-based active surveillance on laboratory-confirmed cases of *Campylobacter*, *Cryptosporidium*,

Cyclospora, *Listeria*, *Salmonella*, Shiga toxin-producing *Escherichia coli* (STEC) O157, STEC non-O157, *Shigella*, *Vibrio*, and *Yersinia*.

After being infected with *Salmonella*, most people develop diarrhea, fever, and abdominal cramps within 12 and 72 hours. Among other foodborne illnesses, Salmonellosis is a significant contributor to morbidity and mortality worldwide with an estimated 93 million cases and 155,000 deaths each year. In the United States, more than 40,000 non-typhoidal *Salmonella (*NTS) infections are reported annually to the Centers for Disease Control and Prevention (CDC); however, many milder illnesses go unreported, thus underestimating the true burden of these infections. For most people, the infection lasts for 4 to 7 days and they recover without any treatment. Generally, the elderly, infants, and those who are immunocompromised are more likely to have a severe illness. And, children are at the highest risk for salmonellosis. According to Centers for Disease Control and Prevention, (CDC, 2004) it is estimated that the rate of salmonellosis (from all sources) among infants is 139.4 cases per 100,000, which is more than eight times greater than the incidence for all other age groups in the United States of America (Maci et. Al, 2015).

In infants and young children, risk factors for salmonellosis differ from adults primarily on dietary patterns and immune abilities (Williams et al, 2015). Many investigators have advised that since the *Salmonella* bacterium is so common in our environment, almost all infants and young children are exposed to them on a daily basis (Schutze et al, 1998). The most important causes of infection may be daily contamination from the environment and sources that affect host resistance (Schutze et al, 1998).

Among children, salmonellosis has been linked to contaminated surfaces and environmental sources such as soil, reptiles, pets and livestock (Williams et al, 2016). Seven

outbreaks of salmonellosis had been linked to animal contact including owls, dairy cattle, rodents, wallabies and horses from 2000 to 2005 in the United States (Williams et al, 2015). Other risk factors include the consumption of undercooked eggs and beef, exposure to antibiotics or antacids, and the consumption of infant formula (Williams et al, 2016). Salmonellosis among humans is commonly associated with exposure to contaminated foods of animal origin or contact with animals carrying *Salmonella* (Younus et al, 2010). According to a few studies, it was reported that the prevalence of *Salmonella* among animals varies by species: from 18% in cats to 36% in dogs and up to 90% in reptiles and amphibians (Younus et al, 2010). Other animal species such as cattle, horses, pigs and birds may also harbor *Salmonella* serotypes that can spread the infection to humans (Younus et al, 2010).

During the early months of life, these risk factors include limited food sources and immature immune status, while between 6 and 18 months, increased exploratory behavior and mobility may lead to acquisition of *Salmonella* from the environment (Schutze et al, 1998). Therefore, the mode of transmission for salmonellosis varies with age: in infants, the most likely transmission route is through passive contact, such as exposure to dust, aerosols or contaminated surfaces at home; in older children, through active contact, such as playing with infected animals; and in adults through eating contaminated foods (Williams et al, 2016).

PURPOSE OF STUDY

In this study, an analysis of childhood salmonellosis comparing infants younger than 6 months of age and those 6 to 12 months old was completed. This analysis was conducted in order to describe and compare exposures among the two age groups. Some of the questions explored in the study are:

- What are the potential exposures of salmonellosis among children younger than 6 months and those 6 to 12 months of age living in Georgia?
- What are the most common environmental exposures reported among *Salmonella* cases from these two age groups?
- How frequently are environmental exposures such as contact with other diapered children, attending large gatherings, daycare attendance and contact with various species of indoor and outdoor animals reported among infants from each segment of this age group?

METHODS

The foodborne disease epidemiology team at Georgia Department of Public Health (DPH) conducts surveillance, participates in applied public health research and compiles data to better understand foodborne diseases. The DPH maintains a list of notifiable diseases, which are required by law to be reported to public health. In 1996, Georgia became a participant in the Emerging Infections Program (EIP) that conducts active surveillance and research studies related to foodborne illnesses and invasive bacterial pathogens.

Together with the Centers for Disease Control and Prevention (CDC), U.S. Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS) and the Food and Drug Administration (FDA), the Georgia Department of Public Health (DPH) participates in Foodborne Diseases Active Surveillance Network (FoodNet), the main foodborne disease component of EIP, to collect information about patients reported to be infected with *Salmonella* , *Campylobacter*, *Cryptosporidium*, *Cyclospora*, *Listeria*, Shiga toxin-producing *Escherichia* coli

(STEC) O157 and non-O157, *Shigella*, *Vibrio* and *Yersinia*. Each FoodNet organism is found on the DPH notifiable disease list. FoodNet is an active surveillance system through which public health officials routinely communicate with clinical laboratories to identify new cases. All patients infected with FoodNet organisms are reported into the State Electronic Notifiable Disease Surveillance System (SENDSS), Georgia's web-based notifiable disease surveillance system. Patients' residence, demographic information, hospitalization status, laboratory methods and results, symptom information, and exposure details are all captured in SENDSS.

Sample

The current analysis is limited to human salmonellosis data from 2014 through 2015. Patient exposure data fields were changed in January 2014 to include new variables requested by FoodNet rendering most of the current exposure variables incomparable to data from previous years. Exposure data from the week before illness onset and detailed clinical data were available for the subset of cases for which interviews were completed. Patients are randomly chosen from an automated system and a minimum of 40% of *Salmonella* cases are attempted to be interviewed at the State Health Department. However, the local districts conduct more than 40% of *Salmonella* case interviews each year.

Variables

The exposure variables used in the study were derived from the list of questions on *Salmonella* Case Interview Form [Appendix]. The questions specifically asked about possible exposures to any of the variables 7 days prior to the start of symptoms. Each question is answered with a yes or no. Animal exposures, such as contact with dog, bird, pig, reptiles/amphibians and cat were included in the study. Environmental exposures, such as contact with others with similar illness, children in diapers and contact with large gatherings were also

studied. Many food exposures were included in the study such as watermelon, chicken, tomatoes, berries, dairy, turkey and beef.

Analysis

In this study, a comparative analysis of salmonellosis was done on infants younger than 6 months and those 6 to 12 months. We were interested in evaluating reported exposures for both infants younger than 6 months and young children 6 to 12 months of age as well as comparing the exposures reported between those two groups. Because children may be given little to no solid food in the first 6 months per American Academy of Pediatrics (AAP) recommendations, we hypothesized the older children (those 6 to 12 months of age) may have more reported food exposures than those younger than 6 months of age. We were also interested in evaluating the possible environmental exposures documented in our data, such as contact with other diapered children and contact with various species of indoor and outdoor animals, in each of the two age groups as well as comparing exposures between the two age groups. Data were downloaded from SENDSS into Microsoft Excel for data cleaning; data management and analysis was conducted using R Statistical Packaging (R-3.2.3) and Epi Info™ 7. The frequencies were derived using Microsoft Excel, Epi Info™ 7 and R Statistical Packaging. Chi-squared tests were used to determine if there was any significant association between the two age groups.

RESULTS

For this study, a total of 1024 cases between the ages of 0-12 months occurring from January 01, 2014 to December 31, 2015 were identified. Among children younger than 6 months, 196 (49.49%) were interviewed and 200 (50.50%) were not interviewed. Children between 6-12 months, 222 (40.07%) were interviewed and 223 (40.25%) were not. However, for children

younger than 6 months, there were 74 (15.74%) cases with missing data; for children 6-12, there were 109 (19.68%) cases with missing data. There were 220 cases (46.80%) reported in 2014 and 250 cases (53.19%) reported in 2015 among children younger than 6 months; there were 273 cases (49.28%) reported in 2014 and 281 cases (50.72%) reported in 2015 among children 6-12 months.

The races for infants under 6 months with salmonella infections included American Indian/Alaska Native (0.25%), Asian (1.50%), Black or African American (21.55%), Multiracial (3.51%), Other (4.01%) and White (69.17%) [Table 1]; for children 6-12 months with salmonella infections, the races included Asian (0.87%), Black or African American (23.81%), Multiracial (2.60%), Other (3.25%) and White (69.48%) [Table 1].

Among children under 6 months, the incidence of Salmonellosis was greatest in August (16.60%) followed by July (15.32%) and September (13.62%) [Figure 1]; among children 6-12 months, the incidence of Salmonellosis was also greatest in August (16.42%), followed by July (15.88%) and September (15.16%) [Figure 2.]. The median age was approximately 3 months among children under 6 months and between children 6-12 months, the median age was about 8 months.

Animal Exposures

All exposure percentages and odds ratios are listed in Table 2. The occurrence of contact with dog was 43.59% among children under than 6 months and for children 6-12 months, the rate of contact with dog was 48.37% (OR=0.82, p =0.33); the incidence of exposure to bird was 1.54% for children under 6 months and among children 6-12 months, the incidence was 2.31% (OR=0.66, p = 0.57). In children under 6 months, the incidence of exposure to pig was 0% and

among children 6-12 months, the rate of exposure was 0.46% (OR=0, p = 0.34); among children under 6 months, the occurrence of exposure to reptile/amphibian was 6.63% and between children 6-12 months, the rate of exposure was 3.67% (OR=1.86, p = 0.17). Among children younger than 6 months, the incidence of contact with cat was 11.40% and for children 6-12 months, the rate of exposure was 15.21% (OR=0.72, p = 0.26).

Environmental Exposures

The occurrence of contact with others with similar illness among children under 6 months was 18.18% and the incidence of contact with others for children 6-12 months was 23.53% (OR=0.72, p = 0.56); for children under 6 months, the rate of exposure to children in diapers was 44.75% and among children 6-12 months, the incidence was 45.77% (OR=0.96, p = 0.84). For children under 6 months, the incidence of attending large gatherings was 18.84% and between children 6-12 months, the rate of exposure to large gatherings was 22.64% (OR=0.79, p = 0.35).

Food Exposures

Among children under 6 months, the incidence of exposure to watermelon was 1.04% and between children 6-12 months, the rate of exposure was 10.95% (OR=0.086, p = <.0001); for children under 6 months, the rate of exposure to chicken was 2.06% and the incidence of contact with chicken among children 6-12 months was 35.85% (OR=0.0389, p = <.0001). The rate of exposure to tomatoes among children under 6 months was 0.52% and the incidence of exposure to tomatoes in children 6-12 months was 3.76% (OR=0.135, p = 0.028); among infants under 6 months, the rate of exposure to dairy was 3.66% and for children 6-12 months, the occurrence of exposure to dairy was 26.29% (OR=0.107, p = <.0001). In children under 6 months, the incidence of exposure to berries was 0.52% and the rate of exposure to berries among children 6-12 months was 13.46% (OR=0.034, p = <.0001); the incidence of exposure to

turkey among children under 6 months was 0.52% and in children 6-12 months, it was 12.38% (OR=0.037, p = <.0001). The rate of exposure to beef in children under 6 months was 1.04% and in children 6-12 months, it was 10% (OR=0.094, p = <.0001).

Table 1. Salmonellosis under 12 months, distribution by races, Georgia, 2014-2015.

RACE	under 6months N (%)	6-12 months N (%)
AMERICAN INDIAN/ALASKA NATIVE	1 (0.25%)	0%
ASIAN	6 (1.50%)	4 (0.87%)
BLACK OR AFRICAN AMERICAN	86 (21.55%)	110 (23.81%)
MULTIRACIAL	14 (3.51%)	12 (2.60%)
OTHER	16 (4.01%)	15 (3.25%)
WHITE	276 (69.17%)	321 (69.48%)

Figure 1. Salmonellosis among children younger than 6 months, distribution by months of disease onset, Georgia, 2014-2015.

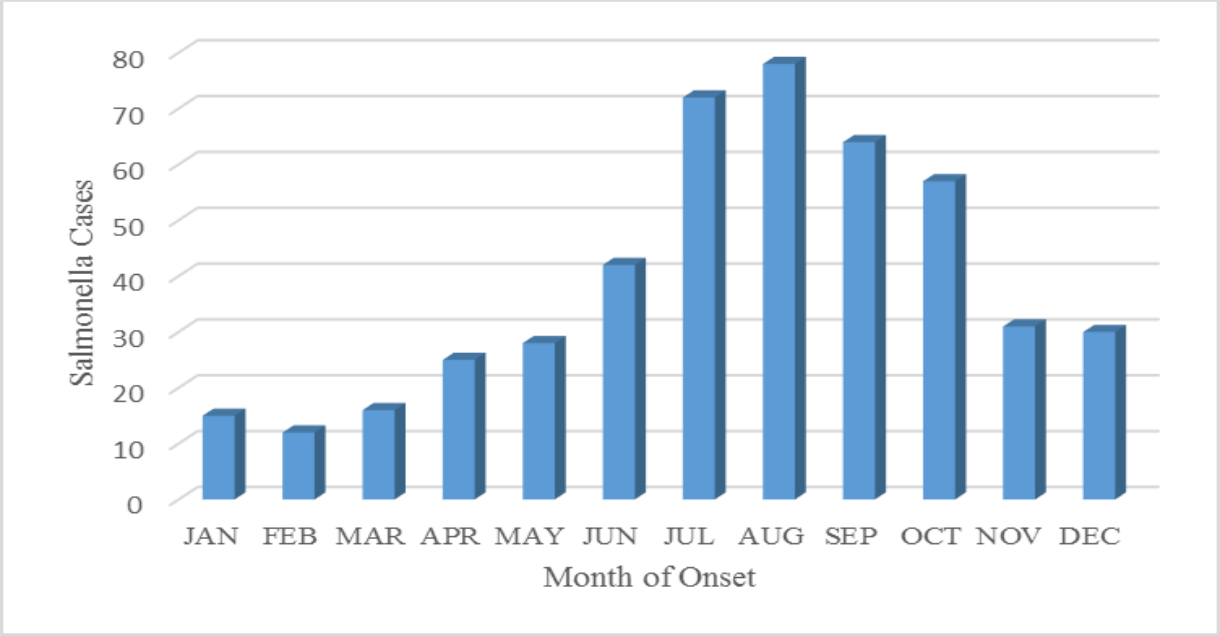

Figure 2. Salmonellosis among children 6-12 months, distribution by months of disease onset, Georgia, 2014-2015.

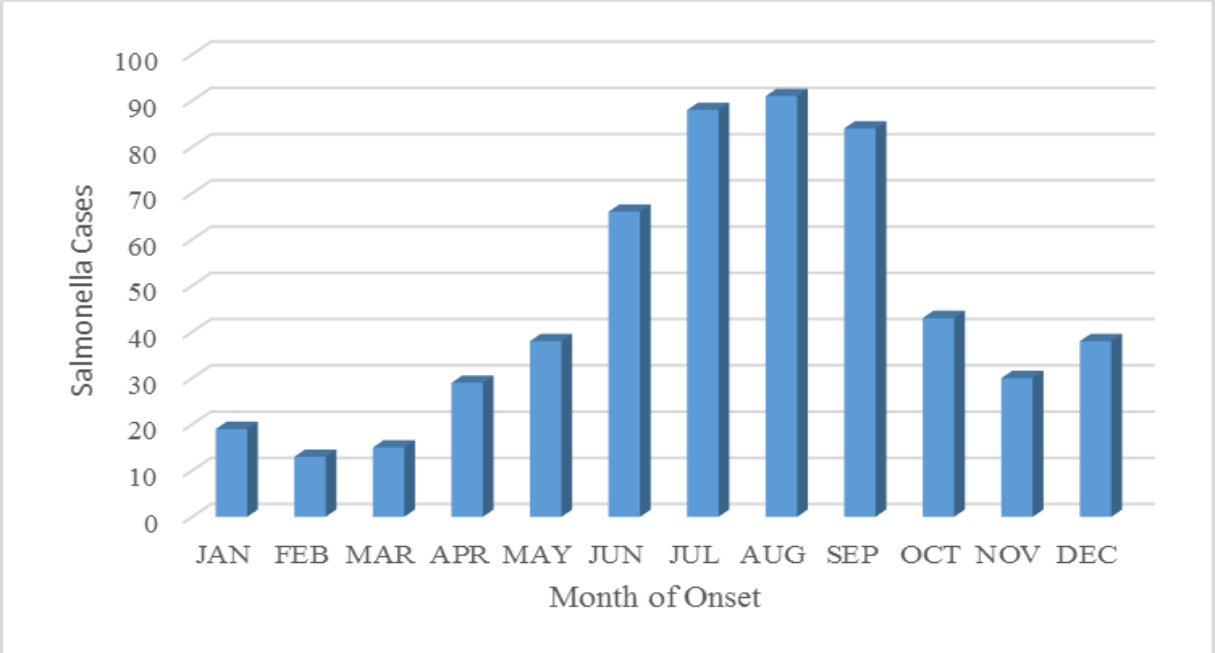

Table 2. Exposure variables for children under 6 months and 6-12 months, Georgia, 2014-2015.

Variable	Under 6 months N=470	6-12 months N=554	p=	Odds ratio 95% CI
Animal Exposures				
Contact with Dog	85 (43.59%) n=195	104 (48.37%) n=215	0.33	0.82 (95% CI 0.56-1.22)
Contact with Bird	3 (1.54%) n=195	5 (2.31%) n=216	0.57	0.66 (95% CI 0.16-2.80)
Contact with Pig	0 (0%) n=195	1 (0.46%) n=216	0.34	0
Contact with Reptiles/ Amphibians	13 (6.63%) n=196	8 (3.67%) n=218	0.17	1.86 (95% CI 0.76-4.60)
Contact with Cat	22 (11.40%) n=193	33 (15.21%) n=217	0.26	0.72 (95% CI 0.40-1.28)
Environmental Exposures				
Contact with others with similar illness	8 (18.18%) n=44	8 (23.53%) n=34	0.56	0.72 (95% CI 0.24-2.17)
Children in diapers	81 (44.75%) n=181	92 (45.77%) n=201	0.84	0.96 (95% CI 0.64-1.44)

Large Gathering	36 (18.84%) n=191	48 (22.64%) n=212	0.35	0.79 (95% CI 0.49-1.29)

Variable	Under 6 months N=470	6-12 months N=554	p=	Odds ratio
Food Exposures				
Watermelon	2 (1.04%) n=192	23 (10.95%) n=210	<.0001	0.086 (95% CI 0.020-0.368)
Chicken	4 (2.06%) n=194	76 (35.85%) n=212	<.0001	0.0389 95% CI 0.013-0.105)
Tomatoes	1 (0.52%) n=191	8 (3.76%) n=213	0.028	0.135 (95% CI 0.017-1.09)
Dairy	7 (3.66%) n=191	56 (26.29%) n=213	<.0001	0.107 (95% CI 0.047-0.240)
Berries	1 (0.52%) n=192	28 (13.46%) n=208	<.0001	0.034 (95% CI 0.005-0.25)
Turkey	1 (0.52%) n=193	26 (12.38%) n=210	<.0001	0.037 (95% CI 0.005-0.274)
Beef	2 (1.04%) n=193	21 (10%) n=210	<.0001	0.094 (95% CI 0.022-0.408)

DISCUSSION

In this study, no animal exposure was seen in more than 50 percent of cases and there was no significant difference in exposure to any single animal type between infants younger than 6 months and those 6-12 months. Moreover, no single environmental exposure was identified in more than 50 percent of cases and there was no significant difference between the two age groups. However, with the exception of tomatoes, we did find statistically significant difference in exposure to foods such as watermelon, chicken, dairy, berries, turkey and beef among children younger than 6 months and 6-12 months. This difference in food exposures may be due to the fact that infants under 6 months are mostly drinking breast milk and infant formula. Additionally, during the first few months of their lives, infants cannot chew or swallow solids, and hence, liquids are usually the primary source for their nutritional needs. Nevertheless, we did find cases in this study where children under 6 months were exposed to solid foods and it may have been due to their developmental readiness.

Babies develop at their own rate and age and size should not be used as the only factors for deciding what to feed them (USDA, 2001). Parents should use mouth patterns and hand and body skills to determine when solid and semi-solid foods can be introduced to young children under 6 months. In general, parents can look for developmental signs in their infants such as the ability to hold up their necks and to sit with support, to bring their lower lips in as a spoon is removed from their mouths, and the capability to keep food in their mouths and swallow it (USDA, 2001).

CONCLUSION

Our findings suggest that there is no difference in animal or environmental exposures among young children 0-12 months. However, infants under 6 months are less likely to have been exposed to foods other than breast milk and infant formula than young children 6-12 months. Even though this study compared the relationship between exposures and salmonellosis among children under 1 year, it is possible that exposure patterns might be similar for other bacterial diseases, such as *Campylobacter*, which is epidemiologically similar to *Salmonella*. Some of the ways in which infant salmonellosis can be prevented are to wash hands before and after changing a child's diaper, to wash children's hands often and thoroughly, especially, after contact with animals and household surfaces, to not allow animals to come in contact with infants, food or surfaces where infant food is prepared, to wash hands before and after infant food preparation and to avoid contact with caregivers who show signs or symptoms of salmonellosis.

Limitations of the study

Because approximately 50% of all cases are interviewed each year and cases are incomplete, many patients were excluded from the study. As a result, our dataset was limited to just one year. Due to the transition from the old case interview form to the current format, it is possible that we may have missed some additional data that could have possibly contributed to the study.

REFERENCES

1. Bandy, U., McCarthy, H., & Hannafin, C. (2003). Reptile-associated salmonellosis: A preventable pediatric infection. *Medicine and Health Rhode Island, 86*(1), 27-9. Retrieved from http://ezproxy.gsu.edu/login?url=http://search.proquest.com/docview/195799173?accountid=11226
2. Bula-Rudas, F.J., Rathore, M.H., Maraqa, N.F. (2015). *Salmonella* infections in Childhood. *Advances in Pediatrics, 62,* 29-58.
3. Centers for Disease Control and Prevention (2015). *Salmonella*. Retrieved March 10, 2016 from http://www.cdc.gov/*Salmonella* /general/index.html
4. Coburn, B., Grassl, G. A., & Finlay, B. B. (2007). *Salmonella*, the host and disease: A brief review. *Immunology and Cell Biology, 85*(2), 112-118. doi:http://dx.doi.org/10.1038/sj.icb.7100007
5. Crim, S.M., Griffin, P.M., Tauxe, R., Marder, E.P., Gilliss, D., Cronquist, A.B., Cartter, M., Tobin-D'Angelo, M., Blythe, D., Smith, K., Lathrop, S., Zansky, S., Cieslak, P.R., Dunn, J., Holt, K.G., Wolpert, B., Henao, O.L; Centers for Disease Control and Prevention (CDC). Preliminary incidence and trends of infection with pathogens transmitted commonly through food—Foodborne Diseases Active Surveillance Network, 10 U.S. sites, 2006–2014. (2015). *MMWR Morb Mortal Wkly Rep*, *64*,18, 495–9.
6. Delarocque-Astagneau, E., Bouillant, C., Vaillant, V., Bouvet, P., Grimont, P., & Desenclos, J. (2000). Risk factors for the occurrence of sporadic *Salmonella* enterica serotype typhimurium infections in children in france: A national case-control study. *Clinical Infectious Diseases, 31*(2), 488-492. Retrieved from http://ezproxy.gsu.edu/login?url=http://search.proquest.com/docview/18482795?accountid=11226
7. Eidelman, A.I., Schanler, R.J., et al., American Academiy of Pediatrics Section on Breastfeeding. Breastfeeding and the use of human milk. (2012). *Pediatrics, 129,* 3, e827-e841.
8. Enserink, R., Mughini-Gras, L., Duizer, E., Kortbeek, T., & Van Pelt, W. (2015). Risk factors for gastroenteritis in child day care. *Epidemiology and Infection, 143*(13), 2707-2720. doi:http://dx.doi.org/10.1017/S0950268814003367
9. Haddock, R. L., Cousens, S. N., & Guzman, C. C. (1991). Infant diet and salmonellosis. *American Journal Of Public Health*, *81*(8), 997-1000. doi:10.2105/AJPH.81.8.997

10. Henao OL, Jones TF, Vugia DJ, Griffin PM; Foodborne Diseases Active Surveillance Network (FoodNet) Workgroup. Foodborne Diseases Active Surveillance Network—2 decades of achievements, 1996–2015. Emerg Infect Dis. 2015 Sep [*date cited*].http://dx.doi.org/10.3201/eid2109.15581.
11. Jones, T. F., Ingram, L. A., Fullerton, K. E., Marcus, R., Anderson, B. J., McCarthy, P. V., Angulo, F. J. (2006). A case-control study of the epidemiology of sporadic *Salmonella* infection in infants. *Pediatrics, 118*(6), 2380-2387. Retrieved from http://ezproxy.gsu.edu/login?url=http://search.proquest.com/docview/19290472?accountid=11226
12. Maci, R., Bijo, B., Xinxo, A., Shehu, F., & Memoci, H. (2015). Prevalence of *Salmonella* spp. in imported powered infant formula (PIF). *Albanian Journal Of Agricultural Sciences, 14*(3), 236-240.
13. Majowicz S.E., Musto, J., Scallan, E., Angulo, F.J., Kirk, M., O'Brien, S.J., Jones, T.F., Fazil, A., Hoekstra, R.M. (2010). The Global Burden of Nontyphoidal *Salmonella* Gastroenteritis. *Clinical Infectious Diseases, 50,* 882-889.
14. Mayo Clinic (2014). *Diseases and Conditions: Salmonella infection.* Retrieved March 16, 2016, from http://www.mayoclinic.org/diseases-conditions/*Salmonella* /basics/causes/con-20029017
15. Mughini-Gras, L., Enserink, R., Friesema, I., Heck, M., Duynhoven, Y. v., & Pelt, W. v. (2014). Risk factors for human salmonellosis originating from pigs, cattle, broiler chickens and egg laying hens: A combined case-control and source attribution analysis. *PLoS One, 9*(2) doi:http://dx.doi.org/10.1371/journal.pone.0087933
16. National Institue of Health. (2015). *Salmonellosis.* Retrieved March 12, 2016, from https://www.niaid.nih.gov/topics/salmonellosis/Pages/default.aspx
17. Rao, P., Riccard, W. & Birrer, D. (2004). Salmonella [Power Point Slides]. Retrieved February 17, 2016 from www.columbia.edu/cu/biology/.../Salmonella.ppt.
18. Rowe, S.Y., Rocourt, J.R., Shiferaw, B., Kassenborg, H.D., Segler, S.D., Marcus, R., Daily, P.J., Hardnett, F.P., & Slutzker, L. (2004). Breast-Feeding Decreases the Risk of Sporadic Salmonellosis among Infants in Foodnet Sites. *Clinical Infectious Diseases, 38,* 262-270.
19. Schutze, G. E., Kirby, R. S., Flick, E. L., Stefanova, R., & al, e. (1998). Epidemiology and molecular identification of *Salmonella* infections in children. *Archives of Pediatrics & Adolescent Medicine, 152*(7), 659-64. Retrieved from

http://ezproxy.gsu.edu/login?url=http://search.proquest.com/docview/198469129?accountid=11226

20. Schutze, G. E., Sikes, J. D., Stefanova, R., & Cave, M. D. (1999). The home environment and salmonellosis in children. *Pediatrics, 103*(1) Retrieved from http://ezproxy.gsu.edu/login?url=http://search.proquest.com/docview/228339457?accountid=11226
21. Shkalim, V., Amir, A., Samra, Z., & Amir, J. (2012). Characteristics of non-typhi *Salmonella* gastroenteritis associated with bacteremia in infants and young children. *Infection, 40*(3), 285-9. doi:http://dx.doi.org/10.1007/s15010-011-0231-4
22. United States Department of Agriculture. (2001). Feeding Infants: A guide for Use in the Child Nutrition Programs. Retrieved May 2, 2016 from http://www.fns.usda.gov/sites/default/files/feeding_infants.pdf
23. Williams, S., Patel, M., Markey, P., Muller, R., Benedict, S., Ross, I., Heuzenroeder, M., Davos, D., Cameron, S., Krause, V. (2015). *Salmonella* in the tropical household environment- Everyday, everywhere . *Journal of Infection,* 71, 642-648.
24. Williams, S., Markey, P., Harlock, M., Binns, P., Gaggin, J., Patel, M. (2016). Individual and household-level risk factors for sporadic salmonellosis in children. *Journal of Infection, 72*, 36-44.
25. World Health Organization (2013). *Salmonella (non-typhoidal).* Retrieved March 20, 2016, from http://www.who.int/mediacentre/factsheets/fs139/en/
26. Younus, M., Wilkins, M. J., Davies, H. D., Rahbar, M. H., Funk, J., Nguyen, C., Saeed, A. M. (2010). The role of exposures to animals and other risk factors in sporadic, non-typhoidal *Salmonella* infections in michigan children. *Zoonoses and Public Health, 57*(7-8), e170-e176. doi:http://dx.doi.org/10.1111/j.1863-2378.2010.01324.x ZIEHM, D., RETTENBACHER-RIEFLER, S., KREIENBROCK, L., CAMPE, A., PULZ, M., & DREESMAN, J. (2015). Risk factors associated with sporadic salmonellosis in children: A case-control study in lower saxony, germany, 2008-2011.*Epidemiology and Infection, 143*(4), 687-694. doi:http://dx.doi.org/10.1017/S095026881400140X

APPENDIX

Salmonellosis Form for Case Follow-up

I. CASE IDENTIFICATION (fill out contact information for the patient)

Name: _____ **County**: _____

Last, First

Address: _____ **Occupation/Grade**: _____

Street (if applicable, collect information about occupational animal exposures)

_____ _____-_____ **Work/Daycare/School**: _____

City Zip Code

Which of the following best describes where your current home is located? (*Please read all options*)

☐ Urban area ☐ Suburban area ☐ Rural area not on a farm

☐ On a farm or on property that borders a farm ☐ Other _____

Home Phone: ( ) _____ **Work Phone**: ( ) _____

II. CASE DEMOGRAPHICS (check the appropriate boxes; fill out date of birth and age in years)

Sex: ☐ Female ☐ Male ☐ Unknown

Race: ☐ White ☐ Black ☐ American Indian/Alaska Native ☐ Asian ☐ Hawaiian/Pacific Islander ☐ Multiracial

Ethnicity: ☐ Hispanic ☐ Non-Hispanic

Date of Birth: ____ / ____ / _____

Other → Please specify _____

Age: _____ years / months / days

III. CLINICAL DATA (check all appropriate boxes)

Date Received First Report: ____ / ____ / _____

Symptomatic: ☐ YES ☐ NO ☐ DK

Physician Name: _____

If yes, **Date of onset**: _____ / _____ / _____

Physician Phone: ( )

Duration of Illness: _____ ☐ Hours ☐ Days

Hospitalized: ☐ YES ☐ NO ☐ Unknown

Symptoms

(list all hospitals, admission and discharge dates)

Diarrhea: ☐ YES ☐ NO ☐ DK

Date of Diarrhea onset: _____ / _____ / _____

Hospital 1: _____

Bloody Diarrhea: ☐ YES ☐ NO ☐ DK

Admission: ___ / ___ / ____ Discharge: ___ / ___ / ____

Vomiting: ☐ YES ☐ NO ☐ DK

Fever: **Temp:**__ ☐ YES ☐ NO ☐ DK

Hospital 2: _____

Nausea: ☐ YES ☐ NO ☐ DK

Admission: ___ / ___ / ____ Discharge: ___/ ___ / ____

Abdominal Pain: ☐ YES ☐ NO ☐ DK

Headache: ☐ YES ☐ NO ☐ DK

Outcome: ☐ **Survived** ☐ **Died** ☐ **Unknown**

Other: ☐ YES ☐ NO ☐ DK

Date of death: ___ / ___ / _____

Specify: _____

IV. POSSIBLE SOURCES OF INFECTION (circle responses and provide details as needed)

A. Potential Sources – refer 7 days prior to onset

1. Are there any stores or markets where you routinely shop for your groceries (including meat, fruit, vegetables, and dairy products)? Y N DK

If yes, please specify: _____

2. Where did you purchase the groceries that you consumed in the week before illness onset? _____

3. Did you/your child eat in a restaurant? Y N DK

4. If you/your child ate in a restaurant, please provide the name(s) and location(s) of the restaurant(s), dates visited, and foods eaten.

Location: _____ Date: ___ / ___ / ____ Food(s): _____

Location: _____ Date: ___ / ___ / ____ Food(s): _____

Location: _____ Date: ___ / ___ / ____ Food(s): _____

5. Did you/your child attend any large gatherings? Y N DK

If yes, please describe: _____

6. Did you have contact with diapered children? Y N DK

7. For children under 1 year:

   Does the child drink formula? Y N DK

If yes, please specify the type of formula: _____

If yes, what type of water is used to mix formula? _____

8. Came in contact with someone with a similar illness? Y N DK

If yes, nature of contact (household, daycare, etc): _____

Names: _____

Specify Date:___/___/___

9. Travel outside of community Y N DK

Date departed: ___/___/___ Date returned home: ___/___/___

Describe location: _____

10. Is the case a food handler? Y N DK

11. Is the case a healthcare worker? Y N DK

12. Is the case a daycare attendee? Y N DK

13. Does the case reside in a nursing home? Y N DK

14. Is the case pregnant? Y N DK

15. Other Y N DK

If yes, specify: _____

B. Suspect Foods – refer to the 7 days prior to onset

(Ask the case if he/she consumed the following in the 7 days prior to onset. Attach additional sheets if necessary.)

1.	…eat chicken or any foods containing chicken?	Y N DK
2.	…eat any chicken made outside of home at a business such as a restaurant, deli, fast food, take-out, or catered event?	Y N DK
3.	…eat any ground chicken?	Y N DK
4.	…eat any turkey or any foods containing turkey?	Y N DK
5.	…eat any turkey made outside of home at a business such as a restaurant, deli, fast food, take-out, or catered event?	Y N DK
6.	…eat any ground turkey?	Y N DK

7.	…eat beef or any foods containing beef?	Y	N	DK
8.	…eat any beef made outside of home at a business such as a restaurant, deli, fast food, take-out, or catered event?	Y	N	DK
9.	…eat any ground beef?	Y	N	DK
10.	…eat any ground beef that was undercooked or raw?	Y	N	DK
11.	…eat pork or any foods containing pork?	Y	N	DK
12.	…eat any fish or fish products (e.g., fish sticks, nuggets, lox, smoked salmon, etc.)?	Y	N	DK
13.	…eat any fish or fish products that was raw or undercooked (e.g., sushi, sashimi)?	Y	N	DK
14.	…eat any seafood (e.g., crab, shrimp, oysters, clams, etc.)?	Y	N	DK
15.	…eat any seafood that was raw or undercooked (e.g., raw oysters, clams, etc.)?	Y	N	DK
16.	…eat any eggs?	Y	N	DK
17.	…eat any eggs made outside of home at a business such as a restaurant, deli, fast food, take-out, or catered event?	Y	N	DK
18.	…eat any eggs that were runny or raw, or uncooked foods made with raw eggs?	Y	N	DK
19.	…eat or drink any dairy products (e.g., milk, yogurt, cheese, ice cream, etc.)?	Y	N	DK
20.	…drink any unpasteurized (or raw) milk?	Y	N	DK
21.	…eat any soft cheese (queso fresco, etc.)?	Y	N	DK
22.	…eat any unpasteurized soft cheese (made from raw milk, such as queso fresco, etc)?	Y	N	DK
23.	…eat or drink any other dairy products that were raw or unpasteurized (e.g., yogurts and ice cream made from raw milk)?	Y	N	DK
24.	…eat any fresh cantaloupe?	Y	N	DK
25.	…eat any fresh watermelon?	Y	N	DK
26.	…eat any fresh (unfrozen) berries?	Y	N	DK
27.	…drink any juice that was not pasteurized and not from a concentrate (often bought from farms or orchards, but may be sold commercially with a label saying it is unpasteurized or raw and may contain bacteria that can cause serious illness)?	Y	N	DK
28.	…eat any fresh, raw lettuce?	Y	N	DK
29.	…eat any fresh (unfrozen), raw spinach?	Y	N	DK
30.	…eat any fresh, raw tomatoes?	Y	N	DK
31.	…eat any sprouts?	Y	N	DK
32.	…eat any fresh (not dried) herbs (basil, cilantro, parsley)?	Y	N	DK
33.	…reside in a home with a septic system?	Y	N	DK
34.	…eat any nuts or nut products?	Y	N	DK
35.	…use water from a private well (on your property or in your neighborhood) as [your/their] primary source of drinking water?	Y	N	DK
36.	…drink any water directly from a natural spring, lake, pond, stream, or river?	Y	N	DK
37.	…swim in, wade in, or enter an ocean, lake, pond, river, stream, or natural spring?	Y	N	DK
38.	…swim in, wade in, or enter a pool, hot tub/spa, fountain, or waterpark with treated water (chlorinated, etc.)?	Y	N	DK
39.	...have a household member or a close contact with diarrhea?	Y	N	DK
40..	…have any contact with a dog?	Y	N	DK
41.	…have any contact with a cat?	Y	N	DK
42.	...have contact with any mammalian household pet other than a dog or cat (e.g. rabbit, guinea pig, ferret, etc.)?	Y	N	DK
43.	…have any contact with a bird, not including live poultry such as chickens or turkeys (e.g., pigeons, gulls, parrots, etc.)?	Y	N	DK
44.	…have any contact with a pet that had diarrhea?	Y	N	DK

45.	…have any contact with a reptile or amphibian (e.g., frog, snake, turtle, etc.)?	Y	N	DK
46.	…visit, work, or live on farm, ranch, petting zoo, or other setting that has animals?	Y	N	DK
47.	…have any contact with any live poultry (e.g., chickens, turkeys, hens, etc.)?	Y	N	DK
48.	…have any contact with any cattle, goats, or sheep?	Y	N	DK
49.	…have any contact with any pigs?	Y	N	DK

Education and Follow-up

- ❑ **Emphasize hand washing and food preparation to case / family.**
- ❑ **Please ask if case can be contacted again in the future for additional questions.**
- ❑ **Ensure environmental health follow-up if any daycare/restaurant or other facility implication.**

V. REPORT COMPLETED

Case Report Completed by: _____

Phone Number: ( ) _____

Date Report Completed: ____ /____ / _____

Date Sent to State: ____ /____ / _____