January 2021

The Impact Of Covid-19 On Backyard Poultry-Associated Salmonella In Connecticut

Laura Kasper
laurakasper90@gmail.com

The impact of COVID-19 on backyard poultry-associated *Salmonella* in Connecticut

Laura Kasper

M.P.H. Candidate in Epidemiology of Microbial Diseases
Yale School of Public Health

First reader: Dr. James Hadler, MD
Second reader: Dr. Linda Niccolai, PhD

Year Completed: 2021
Year Degree Awarded: 2021

Abstract:

Introduction: Salmonellosis is the second leading bacterial foodborne illness in the United States, and is mainly characterized by symptoms of gastroenteritis and their consequences in afflicted individuals. *Salmonella* accounts for 1.35 million infections, 26,500 hospitalizations and 420 deaths in the United States every year. Live poultry act as a reservoir of *Salmonella* and causes an annual national outbreak. There has yet to be a published study on the impact of COVID-19 lockdowns on the incidence of *Salmonella* and on the percentage of cases tied to the national poultry outbreak.

Methods: Active public health surveillance of *Salmonella* in Connecticut is conducted by laboratory surveillance followed by case interview. Surveillance data from Connecticut and the national backyard poultry outbreak in 2014-2019 were used to provide a robust sample for typical *Salmonella* incidence and compared to 2020 data.

Results: There was a significant decrease ($p<0.001$) in the percentage of all confirmed cases from March to May from 23.18% of cases to 12.42%. However, there was a significant increase of cases linked to the national backyard live poultry outbreak in August from 3.85% to 28.00% ($p=0.021$). A statistically significant difference was not observed in demographic or serotype prevalence for either Connecticut cases or those tied to the national backyard poultry-associated outbreak.

Conclusions: The decrease in confirmed cases coincided with the COVID-19 lockdown, and could be due to a transient decrease in healthcare seeking behavior and a decrease in the number of people eating in restaurants. COVID-19 seems to have impacted the seasonal patterns of both overall incidence, as well as those linked to the live poultry outbreak. These findings merit further study and continued attention.

Acknowledgements

I would like to thank my thesis advisors, Dr. James Hadler and Dr. Linda Niccolai, for the guidance that they provided to me over this past year. In addition, I would like to thank the Connecticut Department of Public Health and the Centers for Disease Control for providing me with the data used in this analysis. I'd also like to express my gratitude to the Yale Emerging Infections Programs, particularly my FoodCORE supervisors Tamara Rissman and Nicole Torigian, for their continued support throughout my MPH program. Thank you to the professors at the Yale School of Public Health, specifically those in the Department of Epidemiology of Microbial Diseases, who have given me the tools to be an effective public health professional. Finally, I would like to acknowledge my friends and family who have provided endless support throughout every step of this journey.

Table of Contents:

Introduction:

Foodborne illnesses are a major public health issue that affects 48 million people each year (C.D.C., 2020). *Salmonella* is particularly interesting to study as it is the second leading cause of bacterial foodborne illness in the United States (Foley & Lynne, 2008). Nontyphoidal salmonellosis, which accounts for the majority of salmonellosis cases in the United States, causes symptoms commonly associated with gastroenteritis – including diarrhea, abdominal cramping, vomiting and fever (Giannella, 1996). Animals act as the main reservoir and the disease is usually foodborne, although it can be spread person to person via the fecal-oral route (Giannella, 1996). With *Salmonella enterica* having more than 2,500 unique serotypes, there is considerable diversity in terms of the clinical presentations of salmonellosis (Callaway, Edgrington, Anderson, Byrd, & Nisbet, 2008).

The Centers for Disease Control and Prevention (C.D.C.) estimates that salmonellosis is responsible for 1.35 million infections, 26,500 hospitalizations and 420 deaths in the United States every year (C.D.C., 2020). Even though *Salmonella* infections are typically contracted through contaminated food, they can also be caused from environmental factors. While *Salmonella* species have been isolated in a variety of animals - including cattle, sheep, and reptiles – the link between salmonellosis and host animals is most evident when looking at poultry (Callaway, Edgrington, Anderson, Byrd, & Nisbet, 2008). In addition to exposures from handling store-brought, raw chicken and uncooked eggs in commercial and home kitchens, the incidence of poultry-associated salmonellosis is dependent on case interaction with backyard poultry or their environment (C.D.C.). While *Salmonella* can be found year-round, there is particularly high incidence during the summer months (Collard, et al., 2008) - which coincides with an annual backyard poultry-associated *Salmonella* outbreak (C.D.C. , 2020). Cases are identified as belonging to the national backyard poultry outbreak by having *Salmonella* isolates that are identical by pulse field gel electrophoresis (PFGE) (prior to 2018) and/or whole genome sequencing (WGS) (2018 onwards) with similar allele ranges to other cases with known exposure. The vast majority of these cases (66%) reported having had contact with chicks and ducklings (C.D.C. , 2020).

Since the start of the COVID-19 pandemic, there has been a notable decrease in reported *Salmonella* cases. The root cause of this has not yet been determined, but could likely be due to a decrease in consumption of food from restaurants or a hesitancy in seeking medical treatment. In addition, the Finnish Institute for Health and Welfare has also observed a statistically significant decrease in the number of foodborne illnesses in the period of March-May, 2020. They attributed this decrease to more stringent health and safety measures being put in place (Australian Intitute of Food Safety, 2020). Similar trends were also observed in *Campylobacter* and *Salmonella* incidence in Australia, each was found to be roughly half of the expected amount (Food Safety Information Council, 2020).

While this decrease in foodborne illness in other countries in association with the early phases of the COVID-19 epidemic is noteworthy, there have yet to be formal published studies examining its impact in the United States. The national backyard poultry outbreak in 2020, which has now been characterized, had 1,722 cases reported nationally across all 50 states, with one death (C.D.C. , 2020); 66% of cases reported having contact with chicks or ducklings (C.D.C. , 2020). Cases reported obtaining chicks and duckling from several sources, including agricultural stores, websites and hatcheries. Interestingly, several news outlets reported an increase in online live poultry sales in the age of COVID-19 (Hughes, 2020) (Danovich, 2020) (Gibson, 2020). While data from the national poultry outbreak is now available, there has not yet been a formal reported study examining the impact of COVID-19 on the overall incidence of

Salmonella in the United States from which the national poultry outbreak data can be put in context. The objective of this study is to compare the epidemiology of *Salmonella* in Connecticut in 2020 with that of previous years, and to look at the possible impact of the COVID-19 pandemic on overall incidence and that of the national backyard poultry outbreak.

Methods:

Public health surveillance of foodborne illness in Connecticut is routinely conducted by Connecticut FoodNet and the Yale Emerging Infections Program (EIP) on behalf of the Connecticut Department of Public Health (CT DPH). Active laboratory surveillance for *Salmonella* is conducted based on detection in stool, urine, blood, and other bodily fluids. Following a positive test result, laboratories report the cases to CT DPH and provide basic demographic information – including the case's name, birth date, phone number, address, specimen information and the type of diagnostic test ordered. Interviews are subsequently conducted with case-patients by EIP staff to ascertain additional details, including symptoms, travel history and hospitalization status, as well as determine environmental and food exposures. The interview responses are inputted into the Connecticut Electronic Disease Surveillance System (CTEDSS), which is used to maintain a database of all reportable illnesses in the state. When combined with pulsed-field gel electrophoresis (PFGE) and whole genome sequencing (WGS), the case interview data are used to conduct epidemiological research and determine potential sources of clusters and outbreaks.

In order to examine changes in *Salmonella* incidence, case and interview data from 2014 to 2020 were obtained from CT DPH. Historical data from 2014 to 2019 were used to obtain an average from a robust sample size, which was then compared to 2020 cases. The sample was restricted to laboratory culture-confirmed cases, in order to reflect the cases that are outbreak-associated (which have been culture-confirmed). The dataset included information about demographics, location, specimen collection date, illness onset date, *Salmonella* serotype, exposure to chicken and eggs within 7 days of illness onset, exposure to live poultry within 7 days of illness onset, and whether the case was linked to an outbreak.

The Enteric Zoonotic Activity Team at the Centers for Disease Control (C.D.C.) provided a dataset of Connecticut cases that were linked to the national poultry outbreak between 2014 to 2020. It is important to note that due the manner in which live poultry is shipped within the United States, it is essential to consider all species of backyard poultry when examining changes in incidence. When *Salmonella* cases are linked to the national live poultry outbreak through PFGE and/or WGS, a supplemental interview is performed to collect information about whether the case had exposure to backyard poultry. Further details are also collected about the species of poultry, length of ownership, purchasing location, and the type of exposure the case had (touched enclosure, touched poultry, fed/watered poultry, snuggled/kissed poultry, etc.), as well as demographic information. In Connecticut, cases that report any exposure to live poultry are pre-emptively interviewed with the supplemental poultry questionnaire.

Descriptive analyses, including frequency and percentages, were performed in order to determine whether there was a substantial change in the demographics of individuals testing positive for *Salmonella*. A chi-square analysis was done on all variables to determine statistical significance between the historical trend and 2020 cases – looking at both the groups as a whole, as well as individual sub-categories. Changes in serotype prevalence were done by looking at the 5 most common serotypes, as well as serotypes linked to previous national poultry outbreaks (obtained from MMWR reports). In addition, the number of cases who reported poultry exposure in Connecticut was compared to the official number of Connecticut cases attributed by PFGE and WGS in the national outbreak to determine whether self-reporting poultry exposure was indicative of likelihood to be tied to the national poultry outbreak.

Seasonal changes were examined by looking at the weekly incidence of *Salmonella*, using specimen collection date due to a high number of missing illness onset dates. The average from 2014-2019 was graphed and compared to 2020 weekly incidence. Four periods of the year to be analyzed were determined given the state of the COVID-19 pandemic. January to February was designated to be the pre-lockdown stage and act as a baseline. March through May was the period with the most restrictive lockdown. June through October saw an easing of lockdown restrictions, and finally November to December was looked at following the worsening COVID-19 incidence and return to Phase 2.1 lockdown. Since the *a priori* hypothesis was that the COVID-19 lockdown reduced *Salmonella* incidence, further analysis was done on the March to May period looking at monthly incidence. An odds ratio was calculated using the rest of the year as the reference value.

Results:

Differences in Demographics and Serotype Prevalence

In 2020, the number of *Salmonella* cases dropped from the 6-year average of 468 ± 25 cases to just 330 total cases. As can be seen in Table 1, little was statistically different in the demographic make-up of cases. There was a slight shift towards older individuals testing positive for *Salmonella*, as well as a decrease in individuals who identify themselves as non-Hispanic White from 61.32% to 53.33% (p=0.005). Moreover, there was a decrease in cases who were identified as being associated with any outbreak from 45.62% to 42.73% (p=0.026).

Interestingly, there was a statistically significant increase of more than double the percentage (from 4.02% to 8.79%), of cases self-reporting contact with live poultry. Table 2 indicates the changes in serotype prevalence. There was a slight increase in *S. enteritidis* cases (from 24.15% to 30.61%, p=0.010) and a decrease in *S. typhimurium* cases (from 11.72% to 7.58%, p=0.024). The most statistically significant finding (p<0.001) was an increase in *S. hadar* cases most of whom were linked to a national turtle-associated outbreak.

Trends with Cases Tied to Official Outbreak

Figure 1 illustrates that the percentage of Connecticut cases who self-reported exposure to live poultry within 7 days of their illness onset increasedfrom an average of 4.01 ± 0.71% to 8.79% in 2020. While more cases were reporting live poultry exposure, Table 3 shows how likely cases who self-reported having had poultry exposure within 7 days of their illness onset were to being included in the national poultry outbreak. It must be noted that there was a transition in 2018 from using PFGE to link cases to using WGS. As can be seen in Table 3, following this transition, there was a consistently high proportion of cases who had exposure to poultry that ultimately wound up being included in the national outbreak. Additionally, this could indicate that the number of cases who self-report poultry exposure could be a useful sign to determine how many Connecticut cases will be part of the national outbreak.

Trend in Differences in Demographics of Salmonella Cases in National Poultry Outbreak

Table 4 illustrates the changes in demographics of confirmed Connecticut *Salmonella* cases that have been tied to the national backyard poultry outbreak. There was a statistically significant decrease in cases that did not report having contact with live poultry from 27.78% to

0.00% (p=0.003). While this report is noteworthy, there was a large percentage of cases that either reported unknown poultry exposure or had a missing response (60% in 2020). There was an increase in cases that identify as Hispanic from 3.70% to 16.00%, but this is not quite significant (p=0.055). A significant decrease in cases having unknown values, both sex and race/ethnicity was also noted. However, as in Table 1, there was a lack of statistically significant change in demographics of cases tied to the national backyard poultry outbreak.

Table 5 looks at trends in the type of poultry that the poultry cases had exposure to and length of time they owned that poultry – none of which were statistically significant. However, it is worthwhile to note that of those with complete data, all eight cases in 2020 reported recent poultry ownership (<6 months) compared to 48% (11) of those in the earlier time period. Of those with known contact with live poultry, exposure to chicken appeared to be the most common with 91.30% (21) in 2014-2019 and 70.00% (7) in 2020.

Changes in Seasonality

The most conclusive results come when looking at the changes in seasonality as a result of the COVID-19 lockdowns for all Connecticut *Salmonella* cases. Figure 2 shows that there was a decrease in incidence once Governor Ned Lamont passed an Executive Order on March 16th closing non-essential businesses. Once Phase 2 reopening occurred at the end of May, allowing businesses to open at limited capacity, there was a return to historical levels of *Salmonella* incidence. Table 6 shows the same data categorized by time period and statistical significance in the distribution of cases over time was noted in all time periods except November through December. January through February, the baseline since this was pre-COVID lockdowns, saw an increase from the historical percentage of 9.58% to 14.55% in 2020 (p=0.005). The time period of March through May saw a decrease in cases from 23.18% to 12.42% (p<0.001). This was largely made up by an increase in June-October from 56.48% to 64.24% in 2020 (p=0.007). Because of the decrease in the period between March through May, which fits our *a priori* hypothesis, a further analysis was done to look at monthly differences in that time period (Table 7). The odds ratios indicate that both the April (OR 0.21, 95% CI: 0.10, 0.46) and, to a lesser degree, May (OR 0.41, 95% CI: 0.23, 0.72) had a statistically significant relative decrease in cases.

Figure 3 illustrates the seasonal distribution of Connecticut cases that are tied to the national backyard poultry outbreak. Much like the distribution of Connecticut cases, there appeared to be a seasonal component to those tied to the national outbreak. Table 8 shows the same data categorized by month. Statistical significance was seen in August (p=0.005), October (p=0.009) and November (p=0.034) in 2020 cases, compared with the historical cases from 2014 to 2019. Given that the detection method changed in 2018 from PFGE to WGS, a further analysis was done comparing the different detection method, as can be seen in Figure 4. When only comparing cases that were linked using WGS in 2018 and 2019 as a baseline, we see that there was a statistically significant (p=0.021) increase in cases in August 2020 from 3.85% to 28.00% (Table 9). All of the other time periods were not significant.

Discussion:

My expectation with this study was to observe a rise in poultry-associated *Salmonella* cases during the COVID-19 lockdown period. This could have stemmed from individuals being more interested in using this time at home to raise poultry as pets and/or food sources. In addition, there had been considerable news coverage about the rise in chick and chicken sales during the pandemic (Chea, 2020) (Hughes, 2020) (Danovich, 2020) (Bolanos, 2020) (Nobles-Block, 2020). While 8.79% of 2020 cases reported having contact with poultry, a sharp rise from the average of $4.01 \pm 0.71\%$, the overall number of cases that are tied to the national backyard poultry outbreak has remained relatively constant.

In addition, this study found that there was a shift in the seasonality in 2020 of both overall *Salmonella* incidence in Connecticut, as well as for the cases tied to the national backyard poultry outbreak. In terms of trends in Connecticut as a whole, April saw the greatest restriction, which is understandable given that the lockdown went into effect in mid-March and was eased at the end of May. Part of this could be explained by individuals being hesitant to seek diagnosis and treatment for *Salmonella* symptoms due to fear of contracting COVID-19. A study by Weiner et al found that ambulatory care appointments decreased by 18% between 2019 and 2020, and telehealth use increased from 0.3% to 23.6% (Weiner, Bandeian, & Hatef, 2021). This would have had a large impact on *Salmonella* incidence because only the most ill people were seen in-person. The rise in telehealth visits could have made the logistics of giving a stool sample challenging. Additionally, there has been speculation that contracting *Salmonella* is linked to eating at restaurants and social behavior (Angulo & Jones, 2006), so it stands to reason that incidence would decrease following closures of restaurants and being in a lockdown. It is interesting that *Salmonella* cases had only 0.21 (0.10, 0.46) times the odds of being in April compared to the previous years.

A seasonal shift also emerged when looking at the incidence of cases tied to the national backyard poultry outbreak. The manner by which cases were linked to this outbreak changed in 2018, so these differences were separated for analysis. PFGE was the main method used to link cases to the national outbreak prior to 2018. In the subsequent years, WGS was used. PFGE was a useful took in differentiating between bacterial strains, but it was labor intensive and inconsistent results could be found in different laboratories. When being used to tie cases to a national outbreak, these differences could have a great effect. Unlike PFGE, which looks at the entire genome, WGS allows technicians to focus on a specific gene – increasing the reliability of the test. (Wiesman, et al., 2019) This also provides epidemiologists with the number of allele differences making the comparison between strains more pronounced. In Figure 4, we saw that 2020 cases followed a similar pattern as in 2018-2019 years where WGS was used, with the exception of August. This spike from 3.85% to 28.00% during August is interesting. Future studies should examine whether this could be due to an increase in interactions with live backyard poultry during the warmer months in 2020, or if it was related to an increase in chicken sales.

While there was a decrease in the overall number of *Salmonella* cases in 2020, the demographic distribution was consistent with those in previous years. In spite of this, there was a noteworthy increase in the proportion of individuals self-reporting exposure to live poultry. While exposure to poultry doesn't necessarily mean that live poultry is the root cause of their salmonellosis, it is interesting that there was increased live poultry exposure in 2020. The number of cases exposed to live poultry seems to be indicative of the magnitude of the number of Connecticut cases that are ultimately linked to the national poultry outbreak. Exposure to poultry did not seem to be correlated with the percentage of cases tied to the national poultry outbreak prior to 2018. This changed following the transition to WGS. Data were not available to determine whether the cases who reported exposure to live poultry were those who became part of the national outbreak, but this could be an avenue for future studies.

While this study came with a certain number of limitations, it does illustrate the impact that COVID-19 had on *Salmonella* incidence in Connecticut. Understanding the impact of COVID-19 on other infectious diseases is a valuable pursuit and can help inform public health workers about how lockdown policies impacted transmission and the ability to recognize what happened with less serious infections. Additionally, understanding the demographic distribution of salmonellosis can be useful to create targeted interventions in order to ease the burden, particularly when looking at cases with known poultry exposure.

Limitations:

One of the main limitations of this study is that probable cases were not included in the sample. The sample of overall Connecticut cases was restricted to culture-confirmed cases in order to better reflect the sample from the national poultry outbreak – all of which were culture-confirmed. A case will remain probable if it was unable to be cultured. While the number of probable cases is relatively small (there were only 33 probable cases in 2020), this could artificially deflate the number of true diagnosed *Salmonella* cases in Connecticut, while also providing an additional element of uncertainty with any findings.

Moreover, salmonellosis is not a severe illness and usually clears on its own. This means that individuals who seek treatment for *Salmonella* are only a fraction of the population that are infected, making it challenging to determine the actual number of cases in the population. COVID-19 exasperated this issue given that there was likely a decrease in willingness to seek medical care and challenges with obtaining stool samples from infected individuals in the age of telemedicine. More information on statistics within the reporting pyramid is needed to understand the impact of *Salmonella* at the population-level. Given the small numbers of

Connecticut cases involved in the national poultry outbreak, we only had the power to detect large differences, so it is challenging to discern whether seasonality was impacted by the pandemic.

In addition, the manner by which the questions were asked of cases could have had led to incorrect information being collected. For instance, when looking at the length of poultry ownership in Table 5, we can see that there are strict time categories imposed. Moreover, the question being asked of the case is "How long have you owned or cared for live poultry?" For cases that had previously owned poultry, but recently purchased new additions during the COVID-19 era, they would be categorized as a long-time owner and thus not part of the <6-month subgroup. Both effects combined can make it difficult to conclusively determine when a case purchased live poultry and whether it was during the COVID-19 lockdown period.

Finally, there was a considerable amount of missing data – particularly when looking at demographic information for cases involved with the national poultry outbreak. This study was reliant on interviews of cases and self-reported exposures, which can suffer from recall bias. When the case could not be reached for interview, pertinent information was collected from the primary care provider which could lead to inaccurate or missing data. Exposure to live poultry is not collected as part of pertinent information, and thus would be missing for unreachable cases. Given the small sample size of cases in the national backyard poultry outbreak, this missing data has a substantial effect. Looking at Tables 5 and 6, 50.00% of cases had an unknown exposure to live poultry in 2014-2019 and 60.00% in 2020. Large amounts of missing values were also observed in sex, race/ethnicity, length of poultry ownership, and type of poultry exposure. The sheer amount of missing data had a large effect on the certainty of the findings as it relates to cases involved in the national poultry outbreak. Missing data was also observed in the overall cases, as can be seen in race/ethnicity and contact with live poultry variables in Table 1.

Recommendations:

First, I recommend conducting a study on the chicken sales in the COVID-19 era (March 2020 to December 2020) to determine whether there were months with particularly high number of new poultry purchases as this could explain the increase in *Salmonella* cases tied to the national poultry outbreak in August, October & November.

Second, *Salmonella* cases that report exposure to live poultry, as well as all cases in the national poultry outbreak, should be re-interviewed with a more focused questionnaire to determine the nature of their poultry exposure (length of time exposed, time period of exposure, type of contact with poultry, etc). This would provide researchers with more information about potential routes of transmission in cases with known exposure. It could also help resolve the issues around missing or incomplete data. In making more of an effort to contact cases, either through additional calls or letters, it might be possible to interview more cases and thus not have to rely solely on pertinent information from providers. I also recommend encouraging medical professionals to ask their patients about exposure to live poultry once they test positive for *Salmonella* as this is a common route of transmission of disease. This would allow healthcare professionals to provide this information to public health workers during routine surveillance.

Third, in terms of Connecticut cases, studies should focus on whether cases that reported having live poultry exposure were the same cases that became tied to the national poultry outbreak in order to determine whether exposure is an accurate measure of likelihood of being outbreak-associated. This could be done by requesting additional unique identifiers for the cases in the national outbreak so that they could be merged with a dataset provided by CT DPH. Given that the CT DPH dataset is more complete than that provided by C.D.C., this could also help reduce the impact of missing data.

Additionally, it would be interesting to determine whether there was a change in allele ranges in 2020 as compared to other years using information gathered by whole genome sequencing. With testing of live poultry owned by the case, and comparing that to the WGS results of the case's *Salmonella*, it could be possible to determine whether this exposure was causative.

Finally, future studies should determine if the impact of COVID-19 on the seasonality of salmonellosis was also seen at the national level. This could be accomplished by examining trends in nearby states for both overall *Salmonella* incidence, as well as seasonality of their cases that have been tied to the national backyard poultry outbreak. While these trends have been observed in Connecticut, presence of similar trends in nearby states or on the national level could help inform public health workers to create a targeted intervention to reduce poultry-associated *Salmonella*.

References:

Angulo, F. J., & Jones, T. F. (2006, November 15). Eatng in Restaurants: A Risk Factor for Foodborne Disease? *Clinical Infectious Diseases, 43*(10), 1324-1328.

Australian Intitute of Food Safety. (2020). *Food-borne Illnesses Declining Due to COVID-19 Pandemic*. Retrieved from https://www.foodsafety.com.au/blog/food-borne-illnesses-declining-due-covid-19-pandemic

Bolanos, M. (2020, April 10). *Local Chicken Farms See A Spike In Sales Due to COVID-19*. Retrieved from NPR for Central California: https://www.kvpr.org/post/local-chicken-farms-see-spike-sales-due-covid-19#stream/0

C.D.C. . (2020, September 23). *Outbreaks of Salmonella Infections Linked to Backyard Poultry*. Retrieved from Salmonella Current Outbreaks: https://www.cdc.gov/salmonella/backyardpoultry-05-20/index.html

C.D.C. (2020). *Causes of Food Poisoning*. Retrieved from Foodborne Germs and Illnesses: https://www.cdc.gov/foodsafety/foodborne-germs.html

Callaway, T. R., Edgrington, T. S., Anderson, R. C., Byrd, J. A., & Nisbet, D. J. (2008, April). Gastrointestinal microbial ecology and the safety of our food supply as related to Salmonella. *Journal of Animal Science, 86*, E163-72.

Chea, T. (2020, December 30). *COVID cluckers: Pandemic feeds demand for backyard chickens*. Retrieved from ABC News: https://abcnews.go.com/Business/wireStory/covid-cluckers-pandemic-feeds-demand-backyard-chickens-74966702

Collard, J. M., Bertrand, S., Dierick, K., Godard, C., Wildemauwe, C., Vermeersch, K., . . . Quinet, C. (2008, June). Drastic decrease of Salmonella Enteritidis isolated from humans in Belgium in 2005, shift in phage types and influence on foodborne outbreaks. *Epidemiology and Infection, 136*(6), 771-781.

Danovich, T. (2020, March 28). America Stress-Bought All the Baby Chickens. *New York Times*.

Foley, S. L., & Lynne, A. M. (2008, April). Food animal-associated Salmonella challenges: pathogenicity and antimicrobial resistance. *Journal of Animal Science, 86*(14), 173-187.

Food Safety Information Council. (2020). *Australia's Food Safety Report Card* . Retrieved from https://foodsafety.asn.au/topic/australias-food-safety-report-card-released-for-the-un-world-food-safety-day-7-june-2020/

Giannella, R. A. (1996). *Medical Microbiology*. (S. Baron, Ed.) University of Texas Medical Branch at Falveston.

Gibson, K. (2020, December 30). Pandemic boots demand for backyard poultry folks. *CBS News*.

Hughes, M. (2020, July 25). *The pandemic's unlikely pet: Chickens*. Retrieved from CNN: https://www.cnn.com/2020/07/25/us/pet-chicken-sales-coronavirus-trnd/index.html

Nobles-Block, S. (2020, December 2). *Move over pandemic puppies. COVID chickens are on the rise*. Retrieved from SF Chronicle: https://www.sfchronicle.com/culture/article/Move-over-pandemic-puppies-COVID-chickens-are-on-15769941.php

Weiner, J. P., Bandeian, S., & Hatef, E. (2021, March 23). In-Person and Telehealth Ambulatory Contacts and Costs in a Large US Insured Cohort Before and During the COVID-19 Pandemic. *JAMA Network*.

Wiesman, J., Lofy, K., Lindquist, S., Davis, J., Goldoft, M. J., & Terao, D. (2019, April). Upcoming Transition to Whole Genome Sequencing (WGS). *EpiTrends, 24*(4).

Appendix:

Table 1. Differences in Demographics of Confirmed *Salmonella* cases between 2014-2019 and 2020, Connecticut*

Demographic Criteria	2014-2019 N (%)	2020 N (%)	p-Values
Total	2808	330	-
Sex			
Male	1265 (45.05)	142 (43.03)	NS
Female	1543 (54.95)	188 (56.97)	
Age			
0-4	331 (11.86)	41 (12.42)	NS
5-17	382 (13.60)	42 (12.73)	NS
18-44	931 (33.16)	86 (26.06)	P=0.009
45-64	702 (25.00)	104 (31.52)	P=0.010
65 and over	460 (16.43)	57 (17.27)	NS
County			
Fairfield	855 (30.45)	98 (29.70)	NS
Hartford	631 (22.47)	78 (23.64)	NS
Litchfield	134 (4.77)	19 (5.76)	NS
Middlesex	116 (4.13)	12 (3.64)	NS
New Haven	688 (24.50)	78 (23.64)	NS
New London	179 (6.37)	23 (6.97)	NS
Tolland	96 (3.42)	14 (4.24)	NS
Windham	109 (3.88)	8 (2.42)	NS
Race/Ethnicity			
Asian	110 (3.92)	16 (4.85)	NS
Black	241 (8.58)	38 (11.52)	NS
Hispanic	559 (19.91)	65 (19.70)	NS
White	1722 (61.32)	176 (53.33)	P=0.005
*Other***	48 (1.71)	5 (1.52)	NS
Unknown	128 (4.56)	30 (9.09)	P<0.001
Contact with Live Poultry			
Yes	113 (4.02)	29 (8.79)	P<0.001
No	2081 (74.11)	245 (74.24)	NS
Unknown/Missing	614 (21.87)	56 (16.97)	P=0.040
Outbreak Associated***			
Yes	1281 (45.62)	141 (42.73)	P=0.026
No	1527 (54.38)	217 (57.27)	

* Numbers may not sum due to missing data, and percentages may not sum to 100% due to rounding.
** Includes Native Hawaiian/Pacific Islander, American Indian/Alaska Native, and Multiracial
*** Associated with any outbreak

Table 2. Changes in *Salmonella* Serotype Prevalence, 2014-19 compared to 2020, Connecticut

Serotype	**2014-2019** N (%)	**2020** N(%)	**P-Values**
Enteritidis	678 (24.15)	101 (30.61)	P=0.010
Typhimurium	329 (11.72)	25 (7.58)	P=0.024
Newport	204 (7.26)	19 (5.76)	NS
Infantis	131 (4.67)	18 (5.45)	NS
S. I 4,5,12:i:-	120 (4.27)	10 (3.03)	NS
Thompson	91 (3.24)	13 (3.94)	NS
Javiana	88 (3.13)	8 (2.41)	NS
Braenderup	71 (2.53)	8 (2.42)	NS
Saintpaul	58 (2.07)	5 (1.52)	NS
Oranienburg	53 (1.89)	4 (1.21)	NS
Agona	22 (0.78)	2 (0.61)	NS
Hadar	13 (0.46)	10 (3.03)	P<0.001
Other	970 (34.54)	107 (32.42)	NS

Table 3: Trends with *Salmonella* Cases Reporting Live Poultry Exposure Having Isolates that were Tied to the Official Poultry Outbreak, Connecticut, 2014-2020

Year	Total Number of Cases	Cases Reporting Contact with Poultry	Cases Who Are Tied to National Poultry Outbreak	Percentage Poultry Cases Tied to National Outbreak
2014	464	21	2	9.52
2015	450	17	0	0.00
2016	466	18	13	72.22
2017	437	16	12	75.00
2018	482	15	2	13.33
2019	509	26	25	96.15
2020	330	29	25	86.21

Figure 1: Percentage of Connecticut *Salmonella* Cases Who Self-Reported Exposure to Live Poultry within 7 Days of Illness Onset, 2014-2020

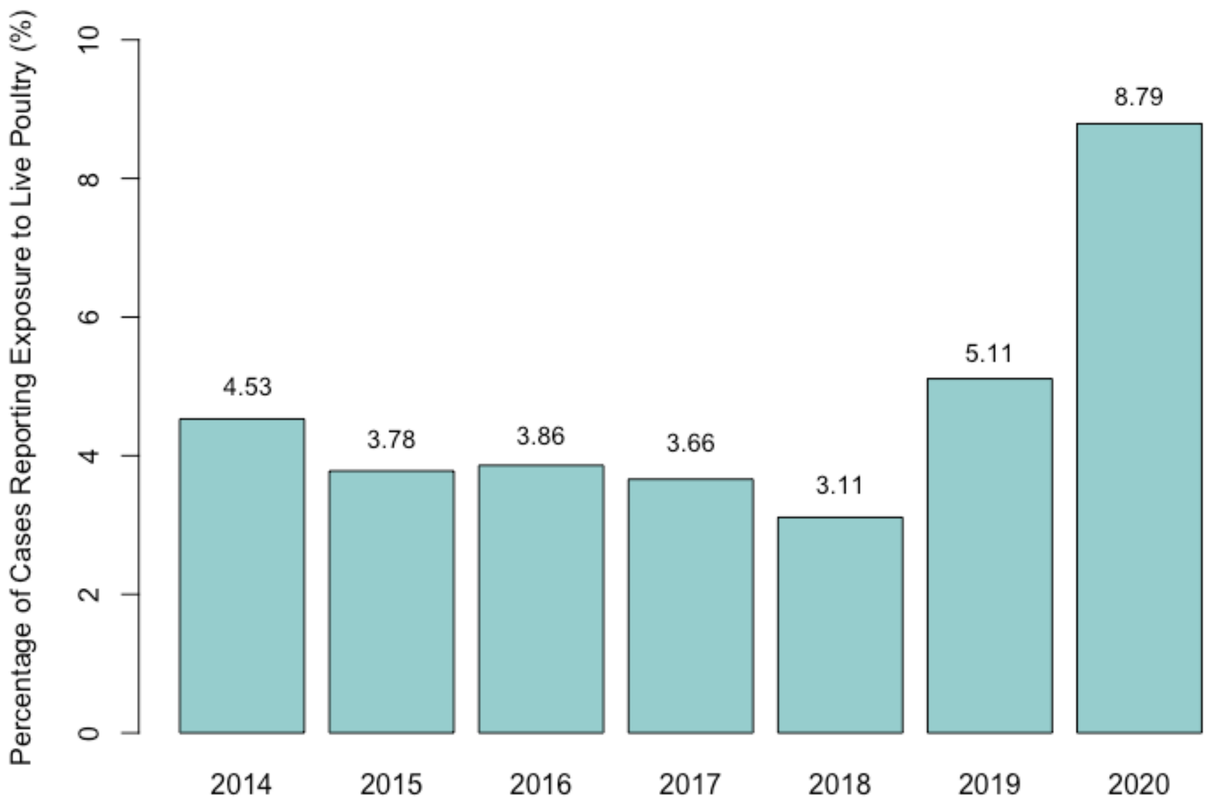

Table 4: Differences in Demographics of Confirmed *Salmonella* cases from Connecticut in the National Poultry Outbreak between 2014-2019 vs 2020*

Demographic Criteria	**2014-2019** N (%)	**2020** N (%)	**p-Values**
Total	54	25	-
Sex			
Male	20 (37.04)	9 (36.00)	NS
Female	24 (44.44)	16 (64.00)	NS
Unknown	10 (18.52)	0 (0.00)	P=0.021
Age			
0-4	8 (14.81)	3 (12.00)	NS
5-17	10 (18.54)	4 (16.00)	NS
18-44	13 (24.07)	7 (28.00)	NS
45-64	16 (29.63)	8 (32.00)	NS
65 and over	4 (7.41)	3 (12.00)	NS
Unknown	3 (5.56)	0 (0.00)	NS
County			
Fairfield	9 (16.67)	9 (36.00)	NS
Hartford	4 (7.41)	3 (12.00)	NS
Litchfield	11 (20.37)	2 (8.00)	NS
Middlesex	4 (7.41)	0 (0.00)	NS
New Haven	9 (16.67)	5 (20.00)	NS
New London	7 (12.96)	1 (4.0)	NS
Tolland	2 (3.70)	1 (4.00)	NS
Windham	5 (9.26)	4 (16.00)	NS
Unknown	3 (5.56)	0 (0.00)	NS
Race/Ethnicity			
Asian	0 (0.00)	0 (0.00)	NS
Black	0 (0.00)	1 (4.00)	NS
Hispanic	2 (3.70)	4 (16.00)	P=0.055
White	31 (57.41)	16 (64.00)	NS
*Other***	4 (7.41)	2 (8.00)	NS
Unknown	17 (31.48)	2 (8.00)	P=0.023
Contact with Live Poultry			
Yes	12 (22.22)	10 (40.00)	NS
No	15 (27.78)	0 (0.00)	P=0.003
Unknown/Missing	27 (50.00)	15 (60.00)	NS

* Numbers may not sum due to missing data, and percentages may not sum to 100% due to rounding.
** Includes Native Haiwaiian/Pacific Islander, American Indian/Alaska Native, and Multiracial

<u>Table 5</u>: Differences in Length and type of Poultry Ownership Among Cases in the *Salmonella* National Poultry Outbreak, 2014-19 vs 2020, Connecticut

	2014-2019 Average N (%)	**2020** N (%)	
Length of Poultry Ownership			
<6 months	11 (20.37)	8 (32.00)	NS
6 months – 1 year	1 (1.85)	0 (0.00)	NS
1 year – 5 years	6 (11.11)	0 (0.00)	NS
>5 years	5 (9.26)	0 (0.00)	NS
Unknown/Missing	31 (57.41)	17 (68.00)	NS
Type of Poultry Exposure			
Chicken	21 (38.88)	7 (28.00)	NS
Turkey	0 (0.00)	0 (0.00)	NS
Duck	1 (1.85)	2 (8.00)	NS
Multiple Types	1 (1.85)	1 (1.85)	NS
None	5 (9.25)	0 (0.00)	NS
Unknown	26 (48.15)	15 (60.00)	NS

<u>Figure 2</u>: Seasonality of Salmonellosis by Date of Specimen Collection, 2014-2019 and 2020, Connecticut

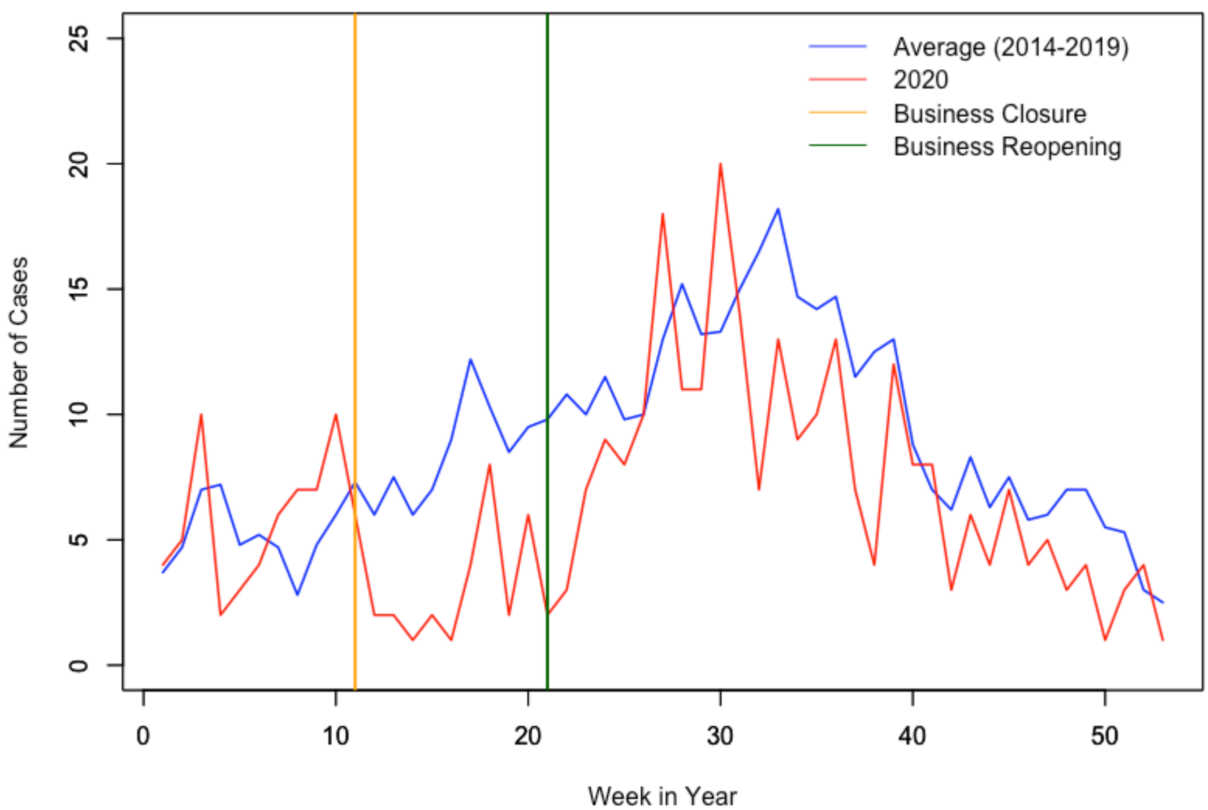

Table 6: Seasonality in distribution of *Salmonella* Incident cases by time period of Specimen Collection, 2014-19 vs 2020, Connecticut

	2014-2019 N(%)	2020 N(%)	p-Values
Full Year			
January – February	269 (9.58)	48 (14.55)	P=0.005
March – May	651 (23.18)	41 (12.42)	P<0.001
June-October	1586 (56.48)	212 (64.24)	P=0.007
November-December	302 (10.75)	29 (8.79)	NS

Table 7: Distribution of *Salmonella* Incident Cases by month of Specimen Collection, March to May, 2014-19 vs 2020, Connecticut

	2014-2019 N(%)	2020 N(%)	OR (95% CI)
Remainder of the Year	2157 (76.82)	289 (87.58)	1.00
March – May Period			
March	168 (5.98)	21 (6.36)	0.93 (0.58, 1.49)
April	245 (8.73)	7 (2.12)	0.21 (0.10, 0.46)
May	238 (8.48)	13 (3.94)	0.41 (0.23, 0.72)

Figure 3: Seasonality of *Salmonella* Cases Linked to Backyard Poultry by Month of Specimen Collection, 2014-19 vs 2020, Connecticut.

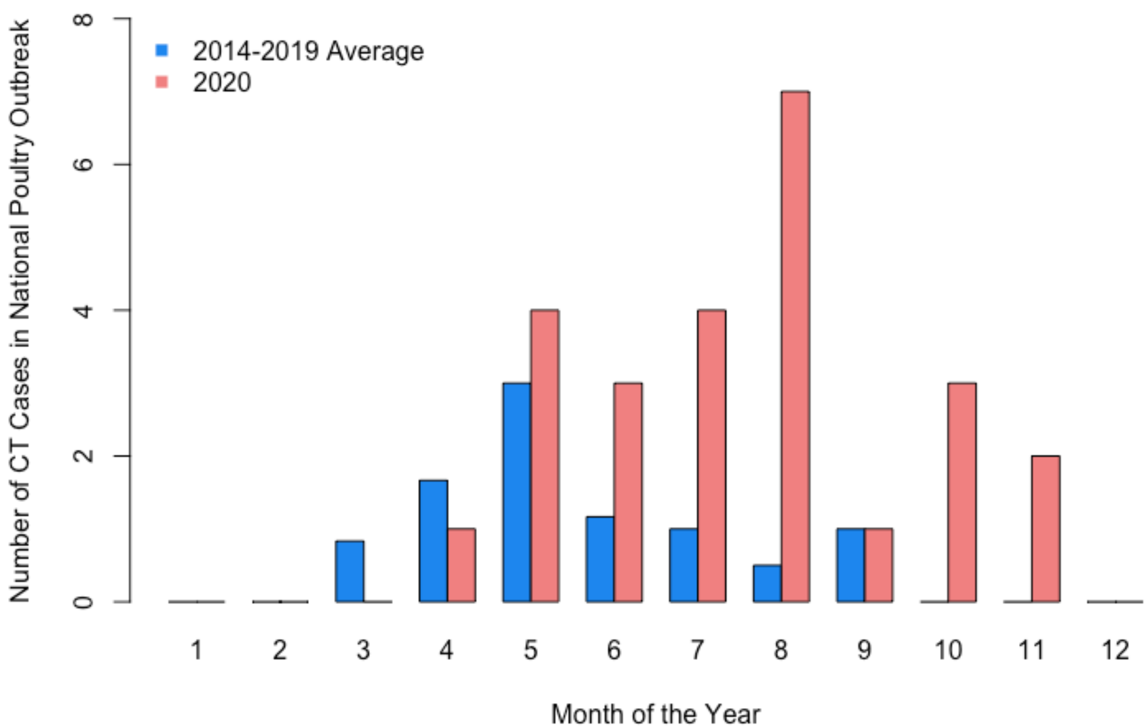

Table 8: Seasonality in *Salmonella* In National Backyard Poultry Outbreak by Specimen Collection Date, 2014-19 vs 2020, Connecticut

	2014-2019 N(%)	**2020** N(%)	**p-Values**
Full Year			
January	0 (0)	0 (0)	NS
February	0 (0)	0 (0)	NS
March	5 (9.09)	0 (0)	NS
April	10 (18.18)	1 (4.00)	NS
May	18 (32.73)	4 (16.00)	NS
June	7 (12.73)	3 (12.00)	NS
July	6 (10.91)	4 (16.00)	NS
August	3 (5.45)	7 (28.00)	P=0.005
September	6 (10.91)	1 (4.00)	NS
October	0 (0)	3 (12.00)	P=0.009
November	0 (0)	2 (8.00)	P=0.034
December	0 (0)	0 (0)	NS

Figure 4: Seasonality of *Salmonella* Cases Tied to Backyard Poultry Outbreak by Detection Method: PFGE (prior to 2018), WGS (2018-2019) vs 2020 (using WGS), Connecticut

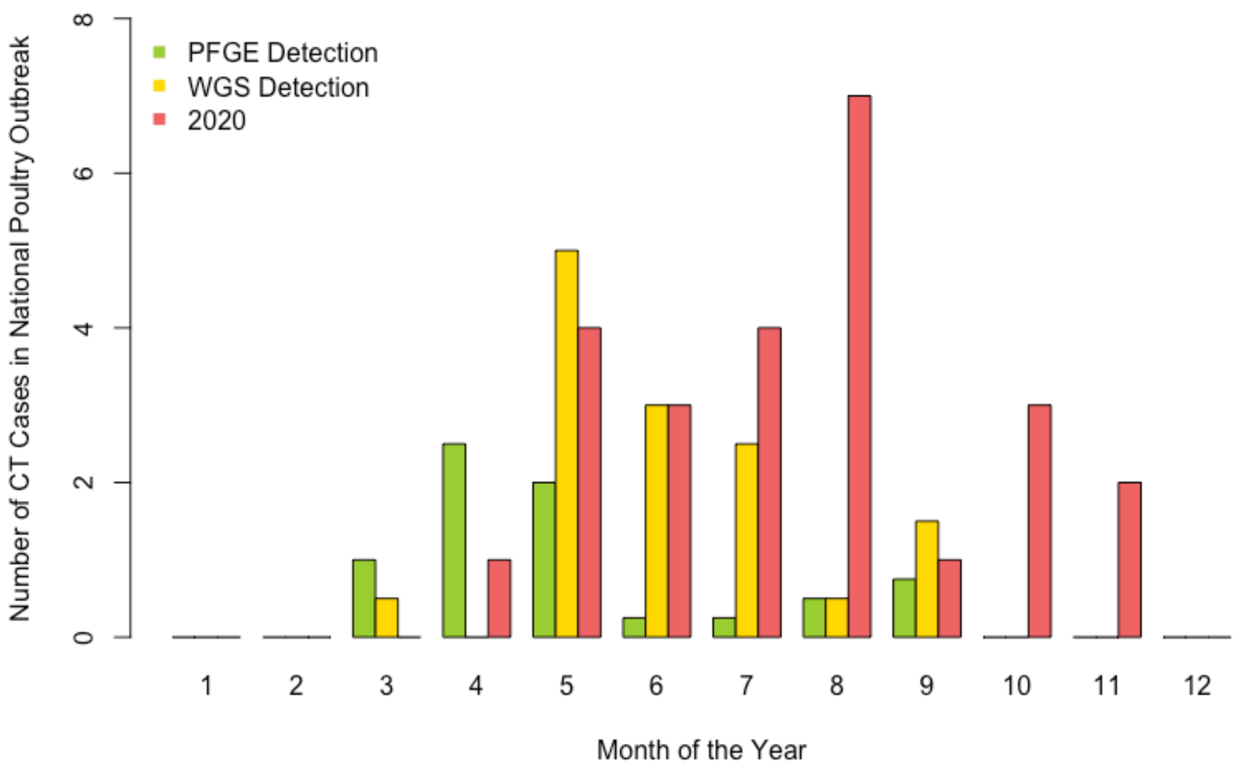

Table 9: Seasonality in *Salmonella* In National Backyard Poultry Outbreak Detected Using Whole Genome Sequencing, 2018-19 vs 2020, Connecticut

	2018-2019 N(%)	**2020** N(%)	**p-Values**
Full Year			
January	0 (0)	0 (0)	NS
February	0 (0)	0 (0)	NS
March	1 (3.85)	0 (0)	NS
April	0 (0)	1 (4.00)	NS
May	10 (38.46)	4 (16.00)	NS
June	6 (23.08)	3 (12.00)	NS
July	5 (19.23)	4 (16.00)	NS
August	1 (3.85)	7 (28.00)	P=0.021
September	3 (11.54)	1 (4.00)	NS
October	0 (0)	3 (12.00)	NS
November	0 (0)	2 (8.00)	NS
December	0 (0)	0 (0)	NS