Trends in *Salmonella* Infantis human illness incidence and chicken carcass prevalence in the USA; 1996-2019

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Introduction

- The incidence of human illness due to *Salmonella* Infantis reported to the Centers for Disease Control and Prevention (CDC) Foodborne Diseases Active Surveillance Network (FoodNet) and the prevalence of Infantis on chicken carcasses reported by the Food Safety Inspection Service (FSIS) have both increased significantly in the past decade.

- However, the trends do not appear coincident, as would be expected if the increased prevalence in chicken led to the increase in the incidence of human illness.

Background

- *Salmonella* Infantis is widespread globally. It is the most detected serovar from animal and food sources in Europe.
- A multidrug-resistant, emergent *Salmonella* Infantis (ESI) was first reported in 2014 in Israel, with subsequent findings of the clone in Eurasia. Subsequent reports and analysis tracked the origins of this clone to South America. The clone has a large plasmid (pESI) that carries several antimicrobial resistance, metal, and virulence genes.
- The increased prevalence of *Salmonella* Infantis isolated from raw chicken and turkey products in the US has been attributed to a single clonal lineage carrying the pESI plasmid. Strains not containing the plasmid are isolated at rates similar to those prior to the emergence of the plasmid.

Data

- This analysis considers the publicly available FoodNet *Salmonella* Infantis data for 1996-2019.

- FSIS has conducted routine sampling of chicken carcasses for *Salmonella* since 1998.

  – Annual summary data are publicly available for 1998-2014 identifying the total number of samples analyzed and the prevalence of the top 10 serotypes.

  – In five years during 1998-2014, the prevalence of *Salmonella* Infantis in chicken carcasses was left-censored, falling below the prevalence of the 10th ranked serotype.

 – Complete serotype data are publicly available for May 2015 through 2019.

Methods

- *Salmonella* Infantis incidence and prevalence trends are analyzed using penalized B-spline methods for generalized additive regression models.
  - Penalized B-spline regression makes no assumptions about the statistical form of trends (Powell 2016. DOI: 10.1111/risa.12530).
  - To account for the left-censored Infantis prevalence data in the regression analysis, bounding analyses are performed with the censored number of Infantis positive carcasses set to either zero or s_{10}-1
- The association between the two time series is analyzed using time-lagged rank order cross-correlation.
  - Rank order correlation does not assume a linear relationship between the two variables.
  - Left-censored prevalence data are modeled as a discrete uniform distribution with number of Infantis positive carcasses = 0, 1, …, s_{10} -1.

Methods

- Differences in the *Salmonella* Infantis incidence during 1996-2019 among 10 FoodNet geographic sites are analyzed by Poisson regression treating site as a categorical variable.
  - Post-hoc comparisons adjusted for 45 possible pairwise comparisons among 10 sites
- Site-specific incidence trends are analyzed using penalized cubic B-spline regression.

Results: Human Incidence
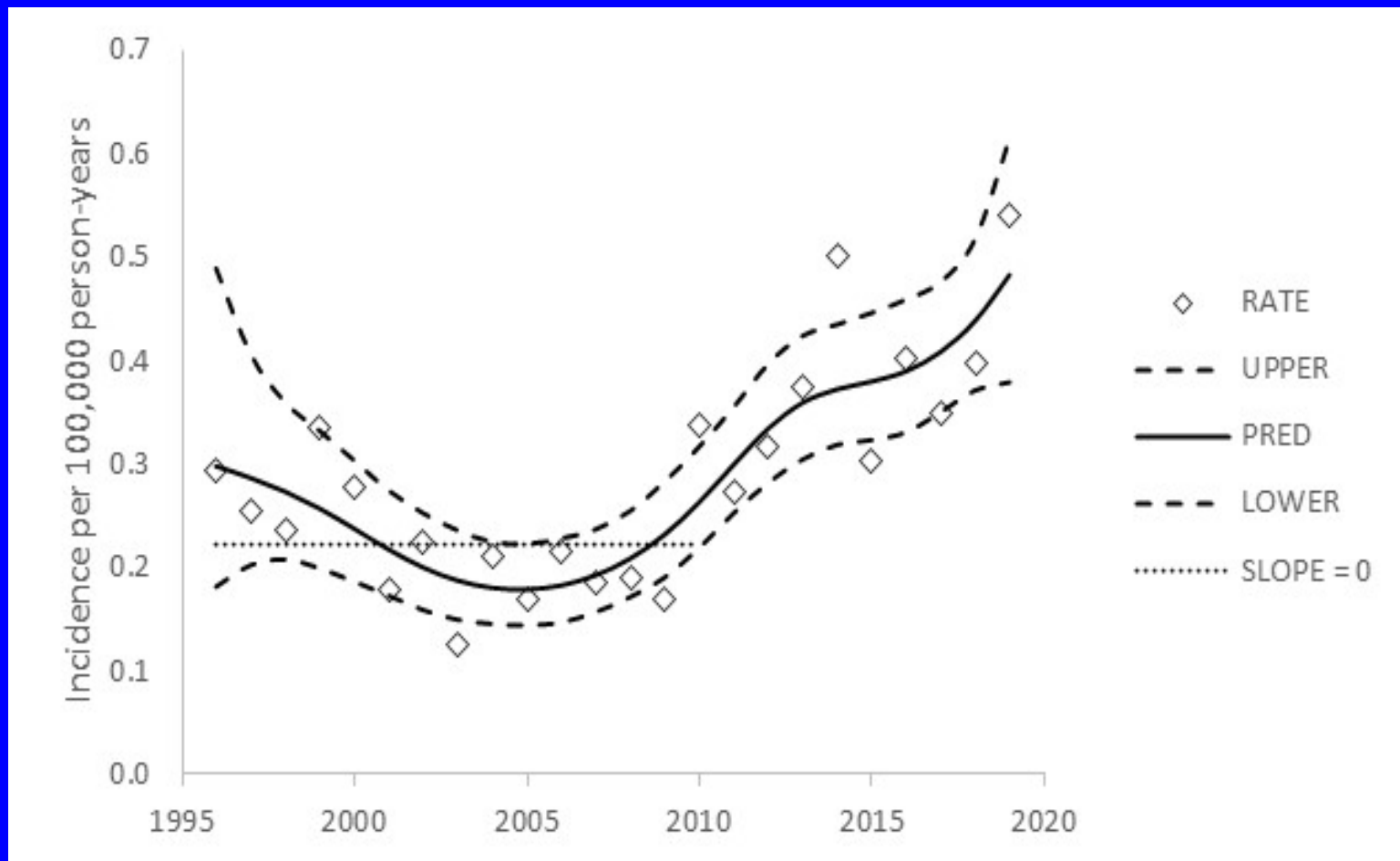
Results: Chicken Prevalence

Fig. 2a Upper Bound Censored Data

Fig. 2b. Lower Bound Censored Data
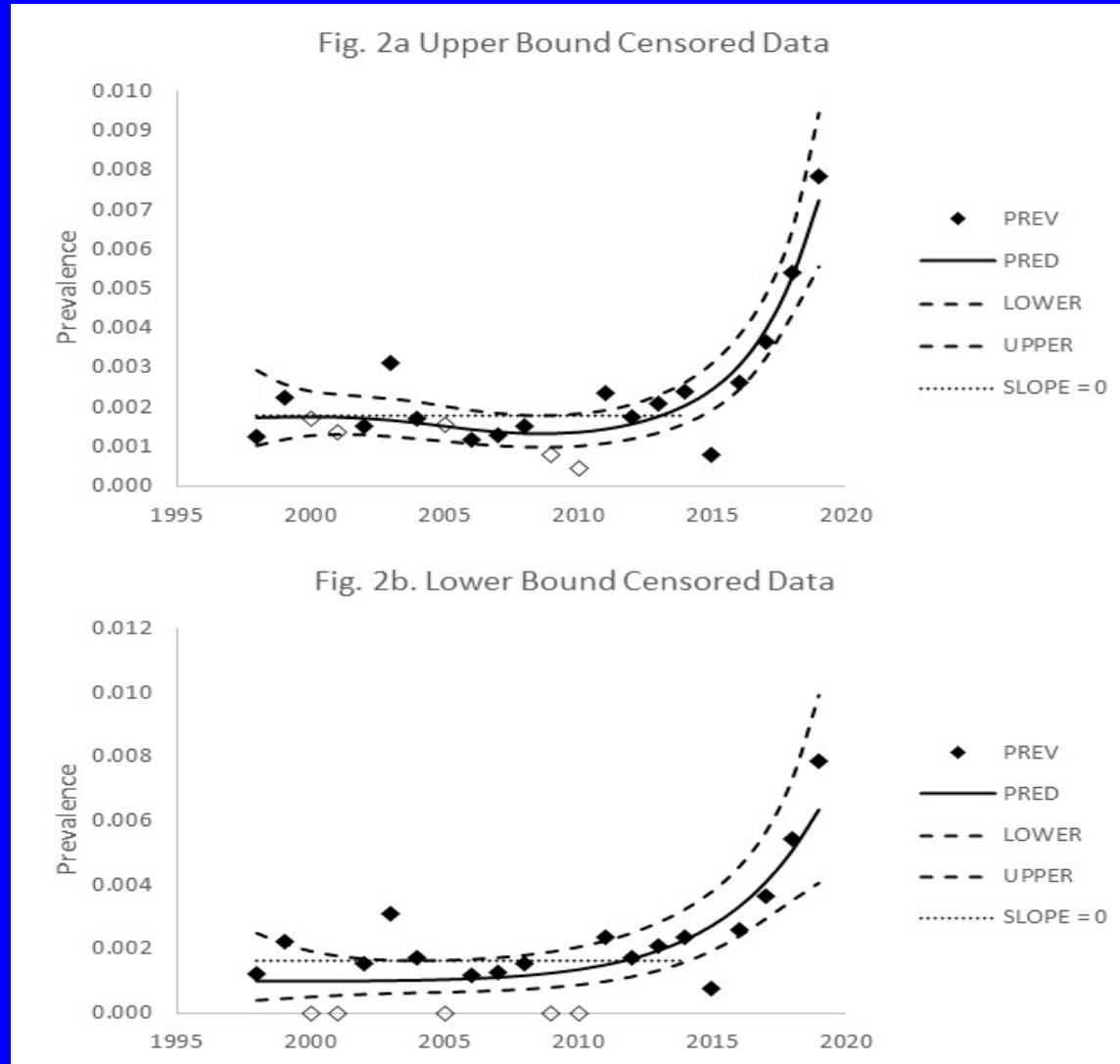
Results: Cross-Correlation

- A 4-year lag on chicken carcass prevalence maximizes rank order cross-correlation with human incidence of illness.

- Consistent with the trend analyses:
  - Increase in human incidence of Salmonella Infantis began circa 2011.
  - Increase in chicken carcass prevalence began circa 2015.

Results: Geographic Variation

- The FoodNet site with the highest incidence is located in the San Francisco, California metropolitan area. The incidence in this site exhibited no significant annual trend during 1996-2019.

- The FoodNet surveillance site with the lowest incidence is Maryland, which exhibited no significant annual trend.

- Incidence in Georgia also exhibited no significant annual trend.

- Increased incidence in remaining sites - not geographically concentrated in a region.

Discussion

- While chicken consumption undoubtedly contributes to the current incidence of human illness due to *Salmonella* Infantis, the initial increase in reported illness was likely due to one or more other transmission pathways.

- Other potential transmission pathways include non-chicken foodborne, waterborne, person-to-person, animal contact, and environmental.

- Persistent, elevated incidence in the San Francisco metropolitan area preceded the first reported detections of the ESI strain in the US.

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Discussion

- Maryland and Georgia are among the leading U.S. states in broiler production. Lack of trend does not support hypothesis that a substantial proportion of illnesses can be attributed to indirect transmission via runoff from a concentration of large poultry production operations.

- Future data acquisition and analysis are needed to estimate the relative contribution of all potential transmission pathways to the current incidence of human illness due to *Salmonella* Infantis.

Disclaimers

The findings and conclusions in this presentation have not been formally disseminated by the U. S. Department of Agriculture and should not be construed to represent any agency determination or policy.

Questions?