Trends in Reported Illness Due to Poultry- and Non-Poultry Associated Salmonella Serotypes; United States 1996-2019

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Introduction

- Despite the reported reduction of Salmonella prevalence in poultry products, the reported overall incidence of Salmonella infection in the United States has not declined since 1996.

- However, temporal patterns vary among Salmonella serotypes:

  – Powell, M., Crim, S., Hoekstra, R., Williams, M., & Gu, W. (2019). Temporal patterns in principal Salmonella serotypes in the USA; 1996–2014. Epidemiology and Infection, 146, 437–441

Purpose

- The objective of the study is to analyze trends in reported illness due to poultry- and non-poultry associated Salmonella serotypes.

Outline

- Time series regression of FoodNet (Foodborne Diseases Active Surveillance Network) Top 10 Salmonella serotypes 1996-2019 divided into two serotype groups: poultry-associated and non-poultry associated.

- Compositional time series analysis of an expanded set of FoodNet serotypes 1996-2019 divided into two serotype groups (chicken-associated and non-chicken associated) as a proportion of culture-confirmed Salmonella

Data

- The analysis considers the available FoodNet Salmonella serotype human annual incidence data for 1996-2019.
  - Data for 2020-2021 are omitted due to the impact of Covid-19 on public health reporting.
- FoodNet Top 10 serotypes associated with poultry are identified based on NACMCF (National Advisory Committee on Microbiological Criteria for Foods, 2023)

Data

- NACMCF (2023): Serotypes associated with poultry - five serotypes in the FoodNet Top 10 serotypes: Enteritidis, Typhimurium, I 4,[5],12:i:-, Infantis, and Heidelberg.

- Remaining five serotypes in FoodNet Top 10: Javiana, Montevideo, Muenchen, Newport, and Saintpaul.

Data

- Extend beyond reported incidence of FoodNet Top 10 serotypes
  - Account for broader set of Salmonella serotypes that predominate in human and chicken meat isolates
- Control for increased use of culture independent diagnostic tests (CIDTs) across time
  - Analyze changing composition of serotypes as proportion of culture-confirmed Salmonella FoodNet reported incidence

Data

- Salmonella serotype information is only available for culture-confirmed cases reported to FoodNet.

- Since 2012, an increasing proportion of Salmonella cases reported to FoodNet have been diagnosed by CIDTs.

- FoodNet separately reports the annual Salmonella count and incidence data for culture-confirmed cases (including cases confirmed following a positive CIDT) and CIDT cases.

Data

- During 1996-2019, the FoodNet Top 10 Salmonella serotypes accounted for 65% of total Salmonella incidence.

- Group of 45 serotypes comprise 95.1% of the serotyped Salmonella cases reported to FoodNet during 1996-2019.

Data: FoodNet Top 45 Salmonella Serotypes

Serotype	% Serotyped	cum
Typhimurium	18.4%	18.4%
Enteritidis	18.4%	36.7%
Newport	11.0%	47.8%
Javiana	7.1%	54.9%
Heidelberg	4.1%	59.0%
I 4,[5],12:i:-	3.8%	62.8%
Montevideo	2.6%	65.5%
Muenchen	2.6%	68.0%
Saintpaul	2.4%	70.5%
Infantis	2.1%	72.6%
Braenderup	1.8%	74.4%
Oranienburg	1.6%	76.0%
Thompson	1.4%	77.4%
Mississippi	1.3%	78.7%
Agona	1.2%	79.9%
Typhi	1.0%	80.9%
Bareilly	1.0%	81.9%
Paratyphi B Var. L(+) Tartrate+	0.9%	82.8%
I 13,23:b:-	0.9%	83.6%
Hadar	0.9%	84.5%
Poona	0.7%	85.2%
Berta	0.6%	85.9%

Serotype	% Serotyped	cum
Mbandaka	0.6%	87.1%
Rough/Nm	0.6%	87.7%
Stanley	0.6%	88.2%
Hartford	0.6%	88.8%
Schwarzengrund	0.5%	89.2%
I 4,[5],12:b:-	0.4%	89.7%
Derby	0.4%	90.1%
Norwich	0.4%	90.5%
Litchfield	0.4%	90.9%
Panama	0.4%	91.4%
Sandiego	0.4%	91.8%
Miami	0.4%	92.2%
Paratyphi A	0.4%	92.5%
Senftenberg	0.3%	92.9%
Paratyphi B	0.3%	93.2%
Dublin	0.3%	93.5%
Adelaide	0.3%	93.8%
Brandenburg	0.3%	94.1%
Rubislaw	0.3%	94.3%
Tennessee	0.3%	94.6%
Reading	0.3%	94.9%
Virchow	0.3%	95.1%

Data

- During 1996-2019, chicken represented 81% of total poultry per-capita food availability.

- Serotypes associated with chicken are based on FSIS (Food Safety Inspection Service) sampling of chicken parts during March 2015 through September 2021.

Data

- Group of ten Salmonella serotypes comprise 95.8% of serotyped chicken parts samples 3/15 – 9/21:

Serotype	% Serotyped	cum
Kentucky	29.5%	29.5%
Enteritidis	24.4%	53.9%
Infantis	17.1%	71.0%
Schwarzengrund	9.2%	80.3%
Typhimurium	8.2%	88.5%
Heidelberg	3.3%	91.8%
Thompson	1.5%	93.3%
Johannesburg	1.0%	94.3%
I 4,[5],12:i:-	0.8%	95.1%
Braenderup	0.7%	95.8%

Methods

- Statistical analyses are divided into two parts.

- The first analysis is a generalized additive model (penalized B-spline regression) of Salmonella serotype incidence trends that produces 95% confidence bands around the estimated curves.

- Powell, M. (2016). Trends in Reported Foodborne Illness in the United States; 1996-2013. Risk Analysis, 36(8), 1589-1598
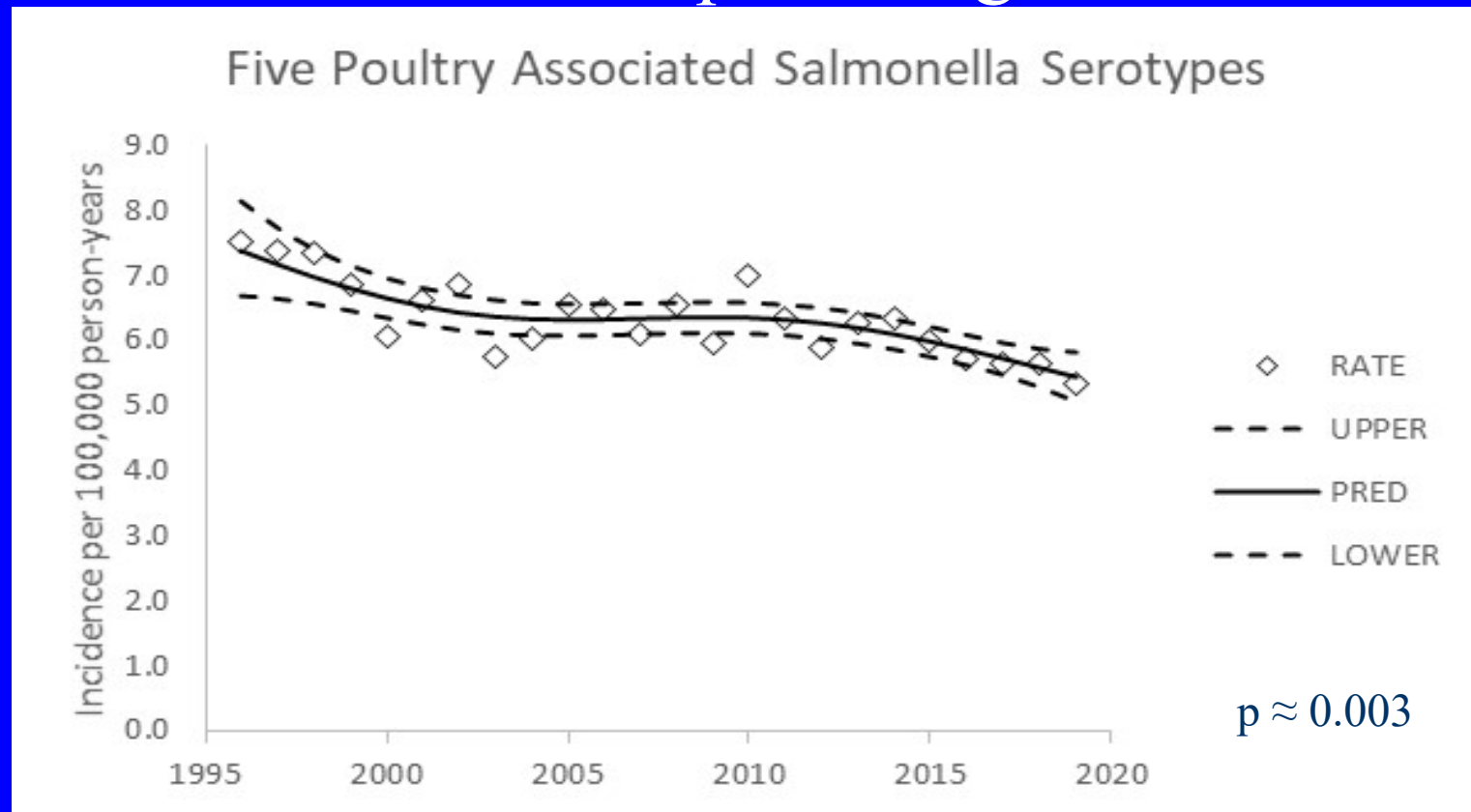
Methods

- The second analysis is a compositional data analysis that evaluates temporal changes in the proportion of culture-confirmed Salmonella incidence due to identified serotypes.

- Compositional data analysis is commonly used in community ecology to analyze differences in the relative abundance of species.

Methods

- Compositional data analysis:
- Transform original incidence data for chicken and non-chicken serotype groups into proportions of culture-confirmed Salmonella incidence
- Trend tested using the non-parametric Mann-Kendall procedure
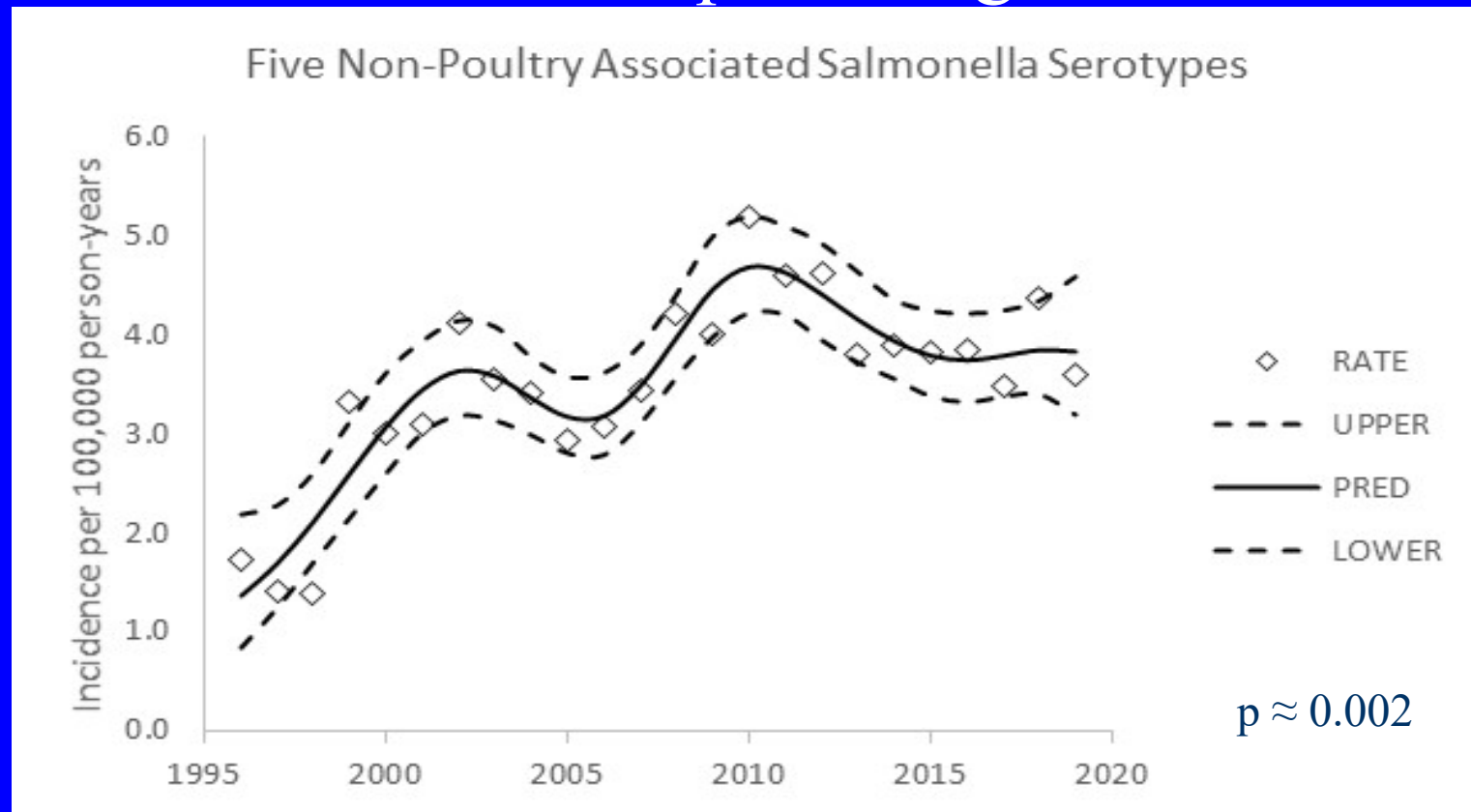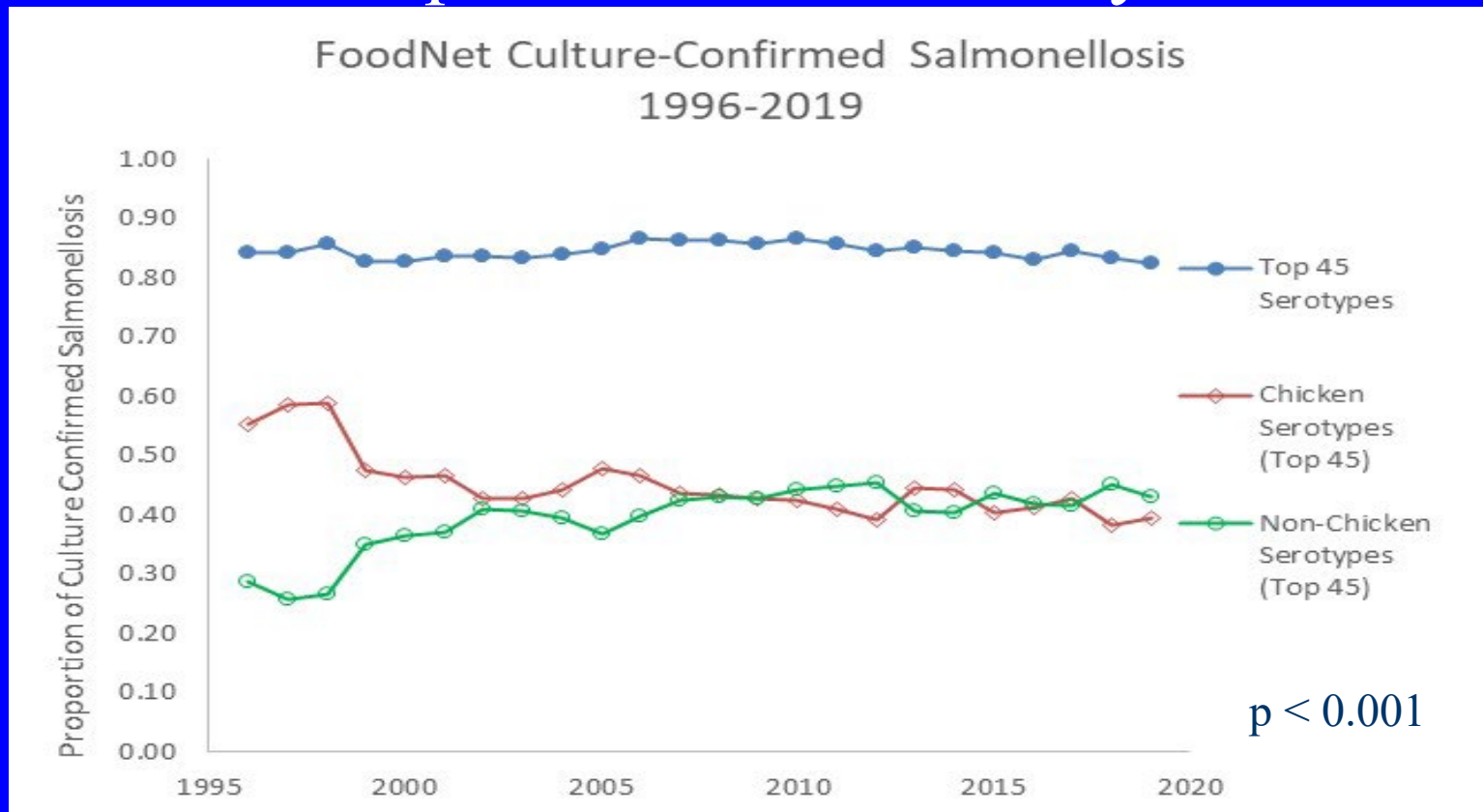
Results

Penalized B-Spline Regression

Five Poultry Associated Salmonella Serotypes

p ≈ 0.003

Results

Penalized B-Spline Regression

Five Non-Poultry Associated Salmonella Serotypes

$p \approx 0.002$

Results

Compositional Data Analysis

FoodNet Culture-Confirmed Salmonellosis 1996-2019

p < 0.001

Results

- Different datasets, different analytical methods yield the same results:
  - Significant declining trends in poultry-associated Salmonella serotypes
  - Significant increasing trends in the Salmonella serotypes not associated with poultry

Discussion

- The analysis underscores an important limitation of previous analyses based on trends in overall Salmonella incidence (e.g., Powell, 2016).

- While the declining trend in the incidence of illness due to poultry-associated Salmonella serotypes is consistent with the reported reduction of Salmonella prevalence in poultry products, it does not necessarily follow that the decline can be attributed to the decreased prevalence in poultry products.

- However, the increasing trend in the incidence of non-poultry associated Salmonella serotypes cannot be attributed to poultry products or to a failure of food safety measures intended to reduce foodborne salmonellosis due to poultry products.

Discussion

- Limitations:
- Scope - illness attribution is not an objective of the study
- Not control for the changing geographic composition of FoodNet sites during 1996-2004
- Reported incidence is a proxy
- Analysis based on crude rates
- Uncertainty about generalizing from FoodNet

Disclaimer

- The findings and conclusions in this presentation are those of the author and should not be construed to represent any official USDA or U.S. Government determination or policy.
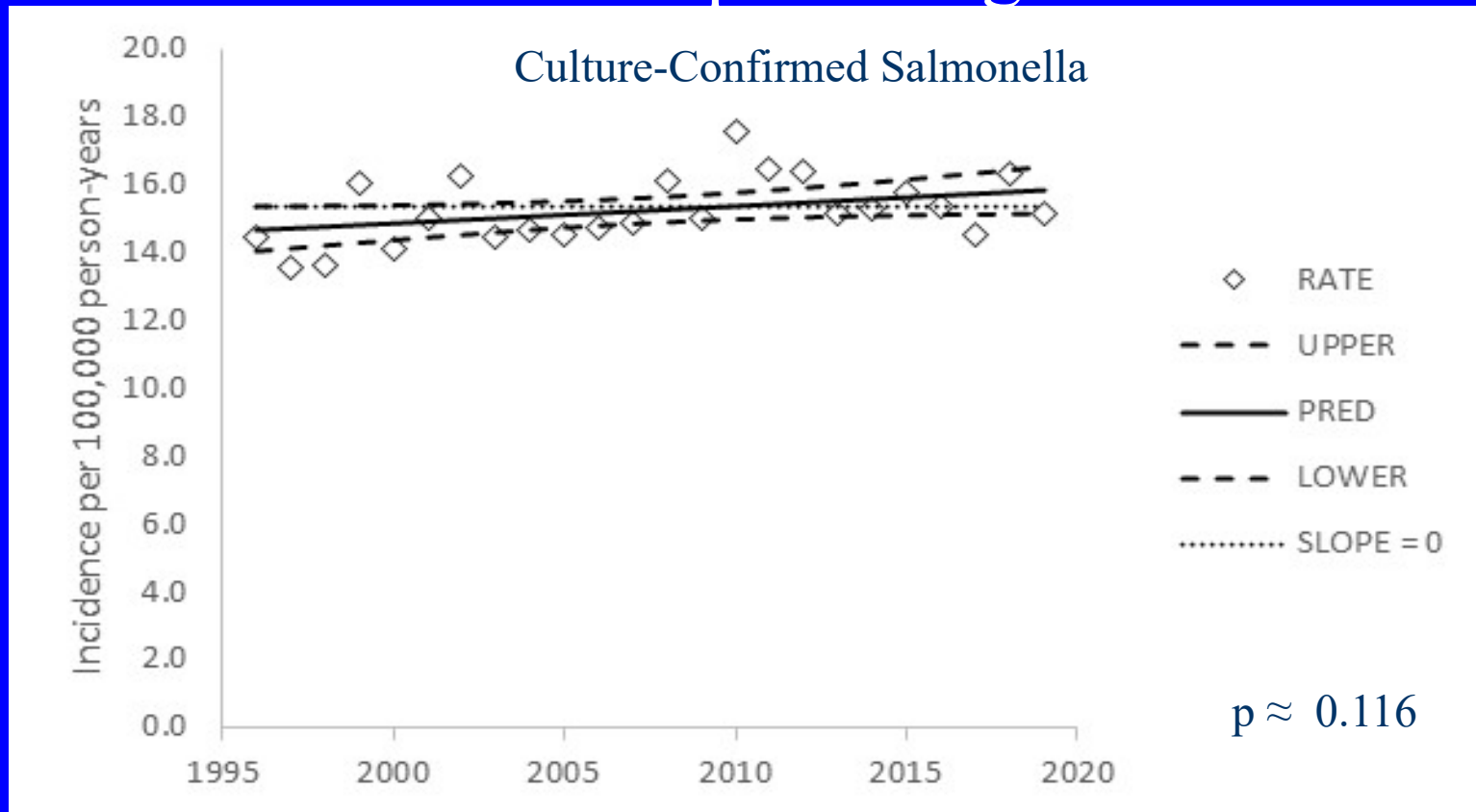
Questions?

- Powell, M. 2023. Trends in reported illness due to poultry- and nonpoultry associated Salmonella serotypes; United States 1996–2019. *Risk Analysis*. DOI: 10.1111/risa.14181

Methods

- Penalized B-spline Regression
  - Semi-parametric method – no assumed trend model form
  - B-spline basis functions provide local control, local fit is insensitive to points far removed
  - Penalized form of B-spline regression is insensitive to number, placement of join-points ("knots")
  - With cubic B-spline basis and second-order difference penalty, generalized linear model is a special case

Results

Penalized B-Spline Regression

Sensitivity Analysis