The relationship between food access and reported *Salmonella* and *Campylobacter* cases in Pennsylvania

A spatial comparison of urban and rural areas

Erica E. Smith, MPH
Department of Epidemiology and Biostatistics/Urban Health Collaborative
Drexel University Dornsife School of Public Health, Philadelphia PA
Introduction

• Nontyphoidal *Salmonella* spp. and *Campylobacter* spp. are major causes of acute gastroenteritis
  • 1,000,000 and 850,000 illnesses annually
  • 1,700 and 1,500 annual cases in PA

• Multiple possible infection sources
  • Contaminated fresh produce items are increasingly recognized as outbreak sources
  • Fresh foods are more likely contaminated than processed/shelf stable foods
Food Access and Healthy Living

- Fresh and healthy foods are important to a healthy diet
  - Limited food access or economic resources can inhibit access

- Enteric illness–food access relationship is complicated
  - Abstaining from fresh food items may be protective
  - Fresh foods in corner stores may be more contaminated
Study Purpose

• Compare *Salmonella* and *Campylobacter* cases by urbanicity

• Compare social determinants by urbanicity
  • Food access and household income

Non-Typhoid *Salmonella*

*Campylobacter* spp.
Data Sources

• Mean annual crude county rates of reported *Salmonella* and *Campylobacter* cases

• Food access measures
  • Supermarket access by distance
    • 500 total individuals or ≥33% of individuals are far from a supermarket (>1 mile away in urban tracts or >10 miles away in rural tracts)
  • Grocery stores by density
    • Count of supermarkets and corner/convenience stores by tract
Data Sources

• Social determinants
  • Urban/rural status
    • “Urban” tract centroid is located in an area with ≥ 2,500 people, all others are “rural”
  • Low income
    • Tract poverty >20% or tract median family income ≤80% of statewide or the metropolitan area’s median family income
Spatial Analyses

• **Urbanicity**
  • County is “urban” if >66% of census tracts were urban

• **Grocery Store density**
  • Number of stores per tract calculated using spatial join
  • Hot spot analysis: tracts with significantly more or fewer stores

• Conducted using ArcMap version 10.4
Statistical Analyses

• Comparison of categorical distributions
  • Chi-Squared or Fisher’s Exact (if any cell count < 5) tests
  • Alpha = 0.05

• Conducted using SAS version 9.4
Mean reported rates of *Salmonella* by county, 2001-2015

<table>
<thead>
<tr>
<th></th>
<th>Urban Counties</th>
<th>Rural Counties</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td><em>Salmonella</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-14 cases/100,000</td>
<td>15</td>
<td>71%</td>
<td>17</td>
</tr>
<tr>
<td>15-20 cases/100,000</td>
<td>5</td>
<td>24%</td>
<td>12</td>
</tr>
<tr>
<td>21-29 cases/100,000</td>
<td>1</td>
<td>5%</td>
<td>3</td>
</tr>
<tr>
<td>Missing</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at alpha = 0.05*
Mean reported rates of *Salmonella* by county, 2001-2015

*Urban county: >66% of census tracts defined as "urban"

Data Source: US Census Bureau TIGER/Line; USDA Food Access Research Atlas; PA Dept of Health Enteric

Prepared by: Erica Smith formatics Exchange

Philadelphia

Pittsburgh
## Mean reported rates of *Campylobacter* by county, 2001-2015

<table>
<thead>
<tr>
<th>Campylobacter</th>
<th>Urban Counties</th>
<th>Rural Counties</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>7-14 cases/100,000</td>
<td>17</td>
<td>81%</td>
<td>11</td>
</tr>
<tr>
<td>15-20 cases/100,000</td>
<td>3</td>
<td>14%</td>
<td>10</td>
</tr>
<tr>
<td>21-29 cases/100,000</td>
<td>1</td>
<td>5%</td>
<td>10</td>
</tr>
<tr>
<td>Missing</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at alpha = 0.05*
Mean reported rates of Campylobacter by county, 2001-2015

*Urban county: >66% of census tracts defined as "urban"

Data Source: US Census Bureau TIGER/Line; USDA Food Access Research Atlas; PA Dept of Health Enterprise Data Dissemination Informatics Exchange

Prepared by: Erica Smith
Food Access and Household Income (census tract)

Food Access*

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Low Access</td>
<td>58%</td>
<td>96%</td>
</tr>
<tr>
<td>Low Access</td>
<td>42%</td>
<td>4%</td>
</tr>
</tbody>
</table>

*significant at alpha = 0.05

Household Income*

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Low Income</td>
<td>9%</td>
<td>2%</td>
</tr>
<tr>
<td>Low Income</td>
<td>34%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Food Access and Household Income*

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both Low Access</td>
<td>58%</td>
<td>96%</td>
</tr>
<tr>
<td>Low Income</td>
<td>42%</td>
<td>4%</td>
</tr>
<tr>
<td>Neither</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*significant at alpha = 0.05
Food Access (census tract)

42% of Urban Census Tracts Have Low Food Access* (1 mile)

4% of Rural Census Tracts Have Low Food Access* (10 miles)

*Low Food Access: >1 mi from grocery store (urban) or >10 mi from grocery store (rural)

Data Source: US Census Bureau TIGER/Line; USDA Food Access Research Atlas

Prepared by: Erica Smith
Food Access and Household Income (census tract)

Household Income*

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Low Income</td>
<td>42%</td>
<td>20%</td>
</tr>
<tr>
<td>Low Income</td>
<td>58%</td>
<td>80%</td>
</tr>
</tbody>
</table>

*significant at alpha = 0.05
Household Income (census tract)

42% of Urban Census Tracts are Low Income*

20% of Rural Census Tracts are Low Income*

Urban Tracts Only

Pittsburgh

Rural Tracts Only

Philadelphia

*Low income: Tract poverty > 20% or Tract median family income < 80% of state or metropolitan area

Data Source: US Census Bureau TIGER/Line; USDA Food Access Research Atlas
Prepared by: Erica Smith
Food Access and Household Income (census tract)

Food Access*  
- Urban: 58% Not Low Access, 42% Low Access, 4% Low Access
- Rural: 96% Not Low Access

Household Income*  
- Urban: 58% Not Low Income, 42% Low Income, 20% Low Income
- Rural: 80% Not Low Income

Food Access and Household Income*  
- Urban: 24% Both, 33% Low Access, 9% Low Income, 78% Neither
- Rural: 18% Both, 18% Low Access, 2% Low Income, 2% Neither

*significant at alpha = 0.05
Food access and household income (census tract)

**Urban Tracts Only**

9% of Urban Census Tracts are both Low Income* and Low Access**

**Rural Tracts Only**

2% of Rural Census Tracts are both Low Income* and Low Access**

---

**Legend**

- **Urban Tracts**
  - Income/Access:
    - Neither
    - Low Income*
    - Low Access**
    - Both

- **Rural Tracts**
  - Income/Access:
    - Neither
    - Low Income*
    - Low Access**
    - Both

---

**Notes**

- Low Food Access: >1 mi from grocery store (urban) or >10 mi from grocery store (rural)
- Low income: Tract poverty > 20% or Tract median family income < 80% of state or metropolitan area

Prepared by: Erica Smith
Data Source: US Census Bureau
TIGER/Line; USDA Food Access Research Atlas
Comparing Distance and Density Measures: Food Access and Grocery Store Hot Spots

Distance

33% of PA Census Tracts are Low Access*

Density

20% of PA Census Tracts have Less Food Access

Hot Spot Food Access Analysis

More Access

Not Significant

Less Access

*Low Food Access: > or >10 mi from grocery

Data Source: US Census Bureau TIGER/Line; USDA Food Access Measure

Prepared by: Erica Smith

Atlas; Mergent Intellect
Results Summary

• Reported foodborne illness cases differed by urbanicity
  • *Campylobacter* cases were more frequently identified in rural counties
    • Consistent with exposures like agricultural animal contact and raw milk

• Social determinants differed by urbanicity
  • Significantly more urban tracts were low food access or low income
    • Only 9% of urban tracts were *both* low income and low food access
  • Among rural tracts, 78% were neither low income nor low food access
Discussion

• Rural tracts appeared to have better supermarket access
  • In the absence of public transportation in rural areas, a distance of 10 miles to a supermarket may still limit access

• Philadelphia vs. Pittsburgh hot spot analysis warrants further consideration
  • This may be driven by paucity of corner stores in Pittsburgh
  • *Salmonella* rates were higher in Philadelphia than Pittsburgh
Limitations

• Interpret these results with caution
  • Exploratory, cross-sectional, aggregate study
  • Dichotomous variables used to measure complex health issues

• Did not account for other causes of enteric disease
  • May also differ by urbanity (e.g. well vs. municipal water)
  • Further planned analyses to include these measures

• Rural counties were more likely to have missing data
  • Statewide average rates may be artificially inflated
Future Research

- Describe social determinants of enteric disease
  - Compare measures of food access
    - Supermarket distance: Different radii, income, vehicle availability
    - Store density: Differentiate between large and small stores
  - Evaluate socio-economic status measures in urban and rural areas
    - Race/ethnicity: new imputation methods when values are missing
    - Household income, education
Future Research

• Describe enteric exposures and social determinants of *Salmonella* and *Campylobacter* by urbanicity
  • A multi-level analysis approach will include:
    • Individual risk factors
      (e.g. animal exposure, unpasteurized dairy, meals outside the home)
    • Neighborhood-level risk factors
      (e.g. urbanicity, supermarket access, corner stores, income, education)
Conclusions

• Both reported cases and social determinants appeared to differ by urbanicity
  • Better tailored public health messaging to prevent sporadic disease

• Programs to address urban food deserts are increasing
  • Proper food handling and storage are necessary
  • Food safety education is needed
Acknowledgements

• Corresponding author:
  Erica E. Smith, MPH
  PhD Student, Epidemiology, Drexel University
  ees73@drexel.edu

Reportable disease data from Pennsylvania Department of Health Enterprise Data Dissemination Informatics Exchange (EDDIE): "These data were provided by the Pennsylvania Department of Health. The Department specifically disclaims responsibility for any analyses, interpretations, or conclusions."
What is a supermarket?

• Reported at least $2 million in annual sales
• Contained all the major food departments found in a traditional supermarket:
  • Fresh produce, fresh meat and poultry, dairy, dry and packaged foods, and frozen foods
How was supermarket distance calculated?

- Tract divided up into $\frac{1}{2}$ kilometer square cells
- Population allocated to grid
- Distance to nearest supermarket calculated from cell
- Cells categorized dichotomously (>1 mi, >10 mi)
Introduction

- **Nontyphoidal Salmonella** spp. and **Campylobacter** spp. are major causes of acute gastroenteritis
  - Symptoms include: diarrhea, abdominal cramps, fever, and nausea/vomiting

- **Sources include food, water and environmental contamination with animal feces**
Salmonella

- Annually
  - 1,000,000 illnesses (US)
  - 1,700 reported cases (PA)

- Outbreaks are common, frequently involve “healthy,” food items
  - Poultry, eggs, nut butters

- Contaminated fresh produce items are increasingly recognized as outbreak sources
Campylobacter

- Annually
  - 850,000 illnesses (US)
  - 1,500 cases (PA)

- Sporadic cases are common

- Sources include
  - Unpasteurized dairy products, contaminated water, poultry, fresh produce
Mean reported rates of *Salmonella* and *Campylobacter* by county, 2001-2015

*Urban county: >66% of census tracts defined as "urban"*

*Prepared by: Erica Smith*

*Data Source: US Census Bureau TIGER/Line; USDA Food Access Research Atlas; PA Dept of Health Enterprise Data Dissemination Informatics Exchange*
Mean reported rates of Salmonella by county, 2001-2015

38% of Urban Counties had Medium or High Rates of Salmonella

34% of Rural Counties had Medium or High Rates of Salmonella

*Urban county: >66% of census tracts defined as "urban"
Mean reported rates of *Campylobacter* by county, 2001-2015

- **14% of Urban Counties** had Medium or High Rates of *Campylobacter*

- **34% of Rural Counties** had Medium or High Rates of *Campylobacter*

*Urban county:* >66% of census tracts defined as "urban"

Data Source: US Census Bureau TIGER/Line; USDA Food Access Research Atlas; PA Dept of Health Enterprise Data Dissemination Informatics Exchange

Prepared by: Erica Smith
## Food Access and Household Income by Census Tract, 2010

<table>
<thead>
<tr>
<th></th>
<th>Urban Tracts</th>
<th>Rural Tracts</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Low Food Access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1037</td>
<td>42%</td>
<td>28</td>
</tr>
<tr>
<td>No</td>
<td>1422</td>
<td>56%</td>
<td>731</td>
</tr>
<tr>
<td>Low Income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Income</td>
<td>1034</td>
<td>42%</td>
<td>153</td>
</tr>
<tr>
<td>Not Low Income</td>
<td>1425</td>
<td>58%</td>
<td>606</td>
</tr>
<tr>
<td>Low Income/Low Access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>211</td>
<td>9%</td>
<td>13</td>
</tr>
<tr>
<td>Low Access</td>
<td>826</td>
<td>34%</td>
<td>15</td>
</tr>
<tr>
<td>Low Income</td>
<td>822</td>
<td>33%</td>
<td>140</td>
</tr>
<tr>
<td>Neither</td>
<td>600</td>
<td>24%</td>
<td>591</td>
</tr>
</tbody>
</table>

*significant at alpha = 0.05
## Food Access and Household Income by Census Tract, 2010

<table>
<thead>
<tr>
<th></th>
<th>Urban Tracts</th>
<th>Rural Tracts</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td><strong>Low Food Access</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1037</td>
<td>42%</td>
<td>28</td>
</tr>
<tr>
<td>No</td>
<td>1422</td>
<td>56%</td>
<td>731</td>
</tr>
<tr>
<td><strong>Low Income</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Income</td>
<td>1034</td>
<td>42%</td>
<td>153</td>
</tr>
<tr>
<td>Not Low Income</td>
<td>1425</td>
<td>58%</td>
<td>606</td>
</tr>
<tr>
<td><strong>Low Income/Low Access</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>211</td>
<td>9%</td>
<td>13</td>
</tr>
<tr>
<td>Low Access</td>
<td>826</td>
<td>34%</td>
<td>15</td>
</tr>
<tr>
<td>Low Income</td>
<td>822</td>
<td>33%</td>
<td>140</td>
</tr>
<tr>
<td>Neither</td>
<td>600</td>
<td>24%</td>
<td>591</td>
</tr>
</tbody>
</table>

*significant at alpha = 0.05