E. coli in the Food System:

- How 7 years of the USDA Coordinated Agricultural Project (CAP) grant has improved understanding and management of the deadly STEC pathogens in the beef chain
- Sampling of STEC-focused knowledge generation across the entire food system

1. Define and describe Shiga toxin-producing Escherichia coli (STEC).
2. Provide the scope, incidence, and impact of STECs in foodborne illness.
3. Present current research on STECs.
4. Discuss mitigation of risk for STEC, with emphasis on the role of consumers and foodservice.

- STEC are a type of pathogenic E. coli that produces a potent toxin called Shiga toxin (Stx), also known as verotoxin or verocytotoxin.
- Stx causes blood vessel damage and plays a key role in other events that result in hemorrhagic colitis (bloody diarrhea), and a type of kidney failure called hemolytic uremic syndrome (HUS) in human patients.
- Strains isolated from human patients with hemorrhagic colitis and/or HUS, and isolates positive for both stx and eae (intimin) genes are known as enterohemorrhagic E. coli (EHEC).
- EHEC, including E. coli O157:H7, are the number one cause of acute end-stage kidney failure in children.

Other key virulence determinants important in infection (especially eae gene), and Stx 2 is more potent than Stx 1.
Hemolytic uremic syndrome (HUS)
Thrombotic Thrombocytopenic Purpura (TTP)

Prior to family BBQ in 2007, Stephanie Smith remains in a wheelchair, fighting to walk -- and dance -- once again. She ate an E. coli tainted hamburger.

2010 financial settlement with the ground beef manufacturer.

One of 158 school children and adults in Britain's 2nd worst E. coli O157:H7 outbreak in 2005.
31 hospitalized, Mason died.
Butcher William Tudor jailed 1 year for breaching food processing hygiene laws.

"E. coli is not just a tummy bug, with sickness and diarrhoea. It completely kills organs. It utterly destroyed Mason's insides," Sharon Mills (mom)

2011 USDA declared 6 other serogroups to beef adulterant list.

"Big 6" "Big 7"
Food borne illnesses account for about 66%

<table>
<thead>
<tr>
<th>STEC</th>
<th>O157</th>
<th>Non-O157</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>All illnesses</td>
<td>96,000</td>
<td>169,000</td>
<td>265,000</td>
</tr>
<tr>
<td>Food borne</td>
<td>63,000</td>
<td>113,000</td>
<td>176,000</td>
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<tr>
<td>Hospitalizations</td>
<td>3,300</td>
<td>400</td>
<td>3,700</td>
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<tr>
<td>Deaths</td>
<td>30</td>
<td>0</td>
<td>30</td>
</tr>
</tbody>
</table>

Increased Recognition of Non-O157 Shiga Toxin-Producing Escherichia coli infections in the United States: Epidemiologic Features and Comparison with E. coli O157 Infections

<table>
<thead>
<tr>
<th>Incidence of Non-O157 STEC infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
</tr>
<tr>
<td>2010</td>
</tr>
</tbody>
</table>

O26 (26%), O103 (22%), O111 (19%), O121 (6%), O45 (5%), and O145 (4%)

Attribution of Food Sources to STEC Infections

Courtesy of Dr. Philip Bronstein, USDA-FSIS

Most Outbreaks of EHEC O157 Infection are Foodborne

Foodborne related cases of illness associated with STEC

STEC attribution to commodity

<table>
<thead>
<tr>
<th>STEC</th>
<th>42%</th>
<th>15%</th>
<th>10%</th>
<th>10%</th>
<th>10%</th>
<th>5%</th>
<th>3%</th>
<th>3%</th>
<th>3%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>O157</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O145</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Foodborne illnesses account for about 66%

INeDENCE OF STEC ILLNESSES IN THE US

(2000-2008)

INeDENCE OF STEC ILLNESSES IN THE US

(2000-2010)
“Shiga-toxigenic Escherichia coli (STEC) in the Beef Chain: Assessing and Mitigating the Risk by Translational Science, Education and Outreach”

United States Department of Agriculture
National Institute of Food and Agriculture
Agriculture and Food Research Initiative
Award Number 2012-68003-30155

THE BEEF CHAIN

Objective Areas:
1. Detection
2. Ecology/Biology
3. Interventions
4. Risk Assessment
5. Education/Outreach

Gate to Plate
Form to Fork
Conception to Consumption

Long Term Goal:
Reduce occurrence and public health risks from STEC-8 (serotypes O26, O111, O103, O121, O45, O145, O157:H7 and O104:H4) in beef using a quantitative microbial risk assessment platform

Pillar 1 - Live cattle 
& beef producers

Pillar 2 – Slaughter, fabrication, 
processing & processors

Pillar 3 - Retail, 
food service & consumers

Objective 1 – Detection: reagents, sampling, assays, technology, partnerships
Objective 2 – Ecology: microbiology, ecology, epidemiology, modifiable risk, battlegrounds
Objective 3 – Interventions: STEC lethality value, feasibility, cost-benefit, impacts
Objective 4 – Risk analysis: risk assessment (QMRA)
Objective 5 – Education, outreach, and evaluation: beef chain and general food safety

STEC COORDINATED AGRICULTURAL PROJECT (CAP)

STEC CAP OBJECTIVES

USDA NIFA AFRI COORDINATED AGRICULTURAL PROJECT
Diagnostic Methods Contributions

Selective Enrichments
Chromogenic Agars
Spiral Plating Method
Genetic-based Testing
Screening vs Confirm
Feces vs Meat/Food
Injury Recovery

Beef Processing Risk Control

7-plex
STEC-7 serogroups
O104
O45
O103
O121
O111
O145
O157
O26

11-plex
STEC-7 + stx1, stx2, eae & ehxA

12-plex
STEC-8 + stx1, stx2, eae & ehxA

Objective 1

RISK ANALYSIS & RISK ASSESSMENT

BEEF PROCESSING RISK CONTROL
US cattle O104 strains are different from the German outbreak strain

- Multiplex PCR did not detect stx 2 nor AggA
- Phylogeny by whole genome microarray did not group together with the German strain
- PFGE types are very different from the German strain, or other human strains
Epidemiology of STEC in Cattle Production Systems

Meta-Analysis Conclusions

- Limited non-O157 serogroup and virulence gene data in cattle
- North America yielded the highest serogroup, STEC, and EHEC estimates
- Worldwide [serogroups O26 and O103 were the most frequently detected]

Identified data gaps in published literature:
1. Data needed for prevalence of non-O157 serogroups and their virulence genes in peri-harvest cattle feces, hides, and carcasses in different cattle types (fed beef, fed dairy, cull beef, cull dairy cattle and veal calves)
2. Concentration data urgently needed to assess human exposure risks
3. Scarce data on feco-hide-carcass microbial contamination pathway
4. Limited data on potential “drivers” of prevalence (e.g., geographical region, season, production system) or variability (e.g., region, feedlot, pen)

Need to Know …
- Prevalence & genetic characteristics of E. coli O104 in cattle at feedlots and harvest
- Data gaps on prevalence & concentration of non-O157 STEC in literature exposed through meta-analysis
- Seasonal aspects of non-O157 STEC prevalence in feedlot cattle
- Regional, feedlot and pen-level variability in prevalence of non-O157 STEC in fed cattle
- Prevalence & concentration of STEC on hides of fed and cull cattle, and on resultant beef carcasses
- Quantification of microbial transfer from hides to carcasses during beef harvesting operations
- Prevalence of STEC in veal calves

- Rule of house flies in ecology of STEC-7 in confined cattle environments
- Mathematical models of transmission dynamics of STEC in cattle
- Analysis and interpretation of bacterial communities [microbiome] within hide swab and fecal samples of cattle at harvest—association of STEC with shifts in communities
- Genetic characterization of STEC O103 isolates from cattle & humans
- Gene expression of STEC O103 during bacterial interaction with bovine rectal epithelial cells
- Prevalence & characterization of E. coli O157:H7 and non-O157 STEC recovered from retail ground veal in Mid-Atlantic region
Summer and winter prevalence of STEC O26, O45, O103, O111, O121, O145, and O157 in feces of feedlot cattle

Diana M. Dewsbury, David G. Renter, Pragathi B. Shridhar, Lance W. Noll, Xiaorong Shi, T.G. Nagaraja, and Natalia Cernicchiaro

Foodborne Pathogens and Disease, 2015

- Some non-O157 serogroups relatively common in cattle feces (e.g., O103); others were not (e.g., O111)
- Few non-O157 STEC were recovered in summer months; most serogroup positive samples did not harbor virulence genes
- No STEC were isolated during the winter months
- Seasonal differences were observed
- Fecal shedding was highly variable between pens of cattle

Regional, feedlot and pen-level variability in prevalence of non-O157 STEC

Charley Cull, David G. Renter, Diana M. Dewsbury, Pragathi B. Shridhar, Lance W. Noll, Xiaorong Shi, Samuel Ives, T.G. Nagaraja, and Natalia Cernicchiaro

- Order of STEC prevalence: O157, O103, O145, O45, O26, O111 and O121
- 100% of feedlots (n=8) and 62% of pens (n=126) had feces positive for O157 STEC, with 100% of feedlots and 23% of pens positive for non-O157 STEC
- No significant differences between states; no statistically significant feedlot-level risk factors (e.g., demographic, dietary, management)
Comparison of Hide and Carcass Prevalence of EHEC-7 in Commercial Feedlot Cattle at Harvest – Summer 2013

Prevalence and concentration of STEC and surrogate microorganisms on hides of fed and culled cattle

David G. Rentier, Sam E. Ives, Lance W. Neil, Pragathi B. Shridhar, and T.G. Nagaraja

OBJECTIVE 2

ENUMERATION OF COLIFORMS FROM PRE-EVISCERATION

ENUMERATION OF COLIFORMS FROM POST-EVISCERATION
OBJECTIVE 3

- Biology of pathogens
- Diagnostic technology development
- Food safety & defense during Processing
- Contamination control and mitigation
- Real pathogens & surrogates

Biosecurity Research Institute (BRI)

Difference Surfaces – Different Stresses – Different Results

- Feedlot Cattle
- Carcass Washing
- Carcass Chilling

- Arrival Slaughter Plant
- Slaughter and Deboning

- Carcass Washing
- Carcass Chilling

- Carcass Washing
- Carcass Chilling

- Carcass Washing
- Carcass Chilling

- Carcass Washing
- Carcass Chilling

- Carcass Washing
- Carcass Chilling

Electrostatic Carcass Spray Cabinet

Chad Carcass Spray Cabinet 180°F Water/Chemical

Carcass Spray Chill or Chemical Appl.

Supporting Attached Microbiology Lab

Fully Equipped Meat Fabrication/Processing Floor

BSL-3 SLAUGHTER & MEAT PROCESSING SUITE AT BRI

- Effect of non-digestible fiber and wet distillers grains on feedlot cattle shedding of STEC (UNL experimental feed yard)
- Efficacy of different approved antimicrobial interventions (e.g., organic acid sprays) in reducing STEC on beef carcasses, fabricated cuts, and head meats (sequencing and multi-hurdle applications)
- Electrostatic spray technology to improve bacterial kill and save water/energy
- Validation of fermentation & heating of dry-fermented sausages to control STEC
- Thermal inactivation of STEC within cubed beef steaks and veal cordon bleu
• Sprayed Lethality in Container (SLIC) method to deliver antimicrobials for STEC onto vacuum packaged beef subprimals
• Translocation & thermal inactivation of STEC in blade tenderized or vacuum tumbled raw beef cuts (e.g. roasts, prime rib)
• Effect of high pressure processing on survival of STEC in beef meatballs and summer sausage
• Effect of deep frying and conventional oven cooking methods on inactivation of STEC in meatballs (veal and/or beef/pork/veal)

• Hide-on carcass traditional and novel intervention validations (Fresno State)
• Dressed carcass chemical spray intervention validations (K-State)
• Breaded veal cutlets cooking and cordon bleu STEC risk profiling studies
• STEC prevalence and characterization in retail ground veal (4 states)
• K-State Beef Cattle Institute veal producer and processor training modules
Comparing STEC Survival in Low- (7%) and High-Fat (30%) Ground Beef During Heating

Findings:
• No differences in survivability across “Big 8” STEC serogroups
• Slightly greater survival of STEC in high-fat ground beef
• Cooking times and temperatures deemed effective for inactivating E. coli O157:H7 equally effective for the other 7 serogroups

Refining Food and Nutrition Science Education through Piloting and Capstone Development

K-State University
University of Nebraska
USDA ERRC

Project Based Learning
• Use the scientific method to develop and conduct research
• Engage high school students in food science, nutrition science and food safety research
• Encourage students to pursue food, nutrition science careers

Exponential Growth Lab
Souderton Increase in STEM Enrollment • 159% since 2010

OBJECTIVE 5

Food and Nutritional Sciences

Souderton (PA) High School’s Pathway 360 Program

Expanded to Coldwater, MI and Dodge City, KS with support of STEC CAP grant

OBJECTIVE 5

Assessing handling practices and perceptions of mechanically tenderized beef

Renee R. Boyer, Benjamin Chapman, Lily Yang, Nicole Arnold, Minh Doung
Labeling requirements – May 2016

- To include descriptive designation
- Easy to read
- Must include validated cooking instructions
  
  • Cooking method
  • Minimum internal temperature
  • Hold times
  • Temperature must be measured

NC State Current Project:

- Collect data related to consumer knowledge & practices of MTB products
- Make recommendations for how to best communicate risks associated with mechanically tenderized beef to consumers – Intervention Methods
- Collect data for STEC- beef risk assessment

LABELING RULES

ULTIMATE GOAL OF OUR WORK

Comparing Methods of Delivery of Food Safety Information to Consumers

- Positive Deviance (PD) focus group method - novel educational intervention that allows participants to discuss their food handling behaviors and decide to try recommended practices modeled after people like themselves.
- Compared PD to personal storytelling and reading standard materials with 89 pregnant women and 93 diabetics.
- Assessed self-reported food safety knowledge, behavioral changes, and hygiene practices pre- and post-intervention through survey.
- Found that PD had higher knowledge scores and adopted more safe handling recommendations. Suggests that food safety education is most effective when delivered in a supportive discussion format.

Dr. Christine Bruhn and Yaohua Feng — UC-Davis

TV Celebrity Chefs as Role Models for Consumers’ Safe Food Handling in the Home

- TV chefs frequently fail to follow recommended food-handling behaviors.
- Study investigated food-handling practices of 4 celebrity chefs (59 shows scoring cook, clean, chill and separate), and consumers’ and culinary students’ attitudes toward mishandling.
- Culinary students believed that chefs should serve as positive role models.
- Consumers viewed celebrity chefs as role models, utilized information transmitted during cooking shows, and practiced behaviors they observed.
- Celebrity chefs’ poor food-handling practices could increase risk of foodborne illness associated with food prepared in the home.

Dr. Christine Bruhn and Yaohua Feng — UC-Davis
Assessment of Risk Communication about Undercooked Hamburgers by Restaurant Servers (Secret Shopper Study)

- It is the duty of food establishments to disclose and remind consumers of risk when ordering undercooked food such as ground beef (FDA Food Code 2013).
- Explored risk communication behaviors of food establishment servers using secret shoppers to visit 265 restaurants in 7 states and ordering medium rare burgers.
- Majority of servers reported an unreliable method of doneness (77%), and 66% of servers provided incorrect (according to Food Code) food safety information to consumer.
- Results demonstrate major gaps in server risk knowledge and support more effective food safety training if servers are to be risk communicators and lead to informed decisions by consumers.

Dr. Ben Chapman and Ellen Thomas... NC State

Objective 5

Purpose (Sneed et al., 2015): Determine impact of “Food Safety Families” clean and separate messages on cross-contamination behaviors of consumers in the kitchen.

- 123 participants randomly assigned to a control group, or one of two food safety message groups.
- All three groups videoed preparing home meal from raw poultry or ground beef, coupled with a hand-cut fruit salad.
- Monitored contamination spread during meal prep microbiologically (Lactobacillus casei) and scored behaviors (video).
- 90% of salads were contaminated and 24% were highly contaminated (levels slightly lower for food safety messages groups).
- Handwashing scores lower for control group.
- Towels were frequently handled by participants and were a primary source of contamination spread.
- External food safety cues had a slight positive effect on behaviors.
- Regardless of group, most participants used procedures resulting in kitchen/food cross-contamination.

Phoebus/Industry Flour Safety and Bakery Products Safety Initiative

- Salmonella and STEC are potential risks in raw flour (including cake mixes) and has led to outbreaks and recalls.
- Flour easily contaminates the kitchen (home, food service, processing plant) environment and can re-contaminate baked goods.
- Working with industry millers to engineer a method of decontaminating wheat prior to milling.
- Working with the baking industry to assess various thermal manufacturing protocols for diverse products for control of Salmonella and STEC.
  - Baking and frying as an effective kill step (5-log cycle reductions).
  - D- and z-value generation for Salmonella and STEC during heating.
  - Generating free online "Kill Step Calculators" for industry to prove/confirm lethality of proprietary baking processes.
  - Determination of survival period of Salmonella and STEC in dry stored flour.
JOIN US FOR FUTURE WEBINARS!
WEDNESDAYS @ 1PM (CT)

2019 WEBINARS

MAR 27  Workforce Development in Food Safety
MAY 15  Food Storage
SEPT 11  Communication
OCT 16  Controlling Costs
NOV 13  Preparing For An Emergency/Disaster

Each are preapproved for 1 hour of Continuing Education Credit by the School Nutrition Association (SNA) and the Certifying Board for Dietary Managers (CBDM).

COMPLETION CERTIFICATES

Certificates will be mailed out within 5-7 business days, following today’s webinar.
For more information and to register:
WWW.FOODHANDLER.COM/EDUCATION-TRAINING

Videos
• Handwashing
• Why To Glove
• When To Glove
• How To Glove

Documents
• Daily Temperature Logs
• Temperature Chart For Safe Food
• Refrigerator Storage Chart
• Food Safety Doesn’t Happen By Accident

Past Blogs
• Politics of Food Safety
• Holiday Health and Food Safety
• Employee Health
• Norovirus

Upcoming Blogs
• Employee Health & Reportable Illness
• Active Managerial Control*
• Coaching & Training Staff
• Productivity

Please Send Us Your Questions Or Comments At:
FOODSAFETY@FOODHANDLER.COM

HOW DID WE DO?
FEEDBACK AND COMMENTS