Six Years of Food Virology Research: The NoroCORE Project

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Scientific Director, USDA NIFA Food Virology Collaborative
Presentation to FDA Southeast Regional Meeting
October 17, 2017
The USDA-NIFA Food Virology Collaborative

- **Long Term Goal:** To reduce the burden of foodborne disease associated with viruses, particularly noroviruses

- **Approach:** Multi-disciplinary team working in an integrated manner to develop improved tools, skills, and capacity to understand and control foodborne virus risks

- **Objectives (Cores):**
  - Molecular virology
  - Detection
  - Epidemiology and Risk Analysis
  - Prevention and Control
  - Extension and Outreach
  - Education and Capacity Building
Molecular Virology: Develop improved methods to facilitate the study of foodborne viruses and to further elucidate the significance of viral foodborne disease

Detection: Develop and validate sensitive, rapid, and practical methods to detect and genotype human norovirus in relevant sample matrices

Epidemiology and Risk Analysis: Collect and analyze population data on the burden of virus-associated disease, including epidemiological attribution and characterization of risk and costs

Prevention and Control: Improve understanding the occurrence and behavior of human norovirus in the food safety continuum so as to inform development of scientifically justifiable control measures
Extension, Outreach, & Education Activities

- **Extension and Outreach:** Translate and disseminate new knowledge about foodborne viruses into practices that reach target audiences in relevant work environments and across a wide array of stakeholder groups.

- **Capacity Building:** Build scientific and human capacity to support increased and sustained efforts in food virology by fostering information and exchange, expanding professional capacity through formal student education and training initiatives.
Partners (Collaborators)
Stakeholders
Replication of human noroviruses in stem cell-derived human enteroids

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Umesh Karandikar,1 Victoria R. Tenge,1 Frederick H. Neill,1 Sarah E. Blutt,1
Xi-Lei Zeng,1 Lin Qu,1 Baijun Kou,1 Antone R. Opekun,2,3,4 Douglas Burrin,3,4
David Y. Graham,1,2,5 Sasirekha Ramani,1 Robert L. Atmar,1,2 Mary K. Estes1,2†

The major barrier to research and development of effective interventions for human noroviruses (HuNoVs) has been the lack of a robust and reproducible in vitro cultivation system. HuNoVs are the leading cause of gastroenteritis worldwide. We report the successful cultivation of multiple HuNoV strains in enterocytes in stem cell-derived, nontransformed human intestinal enteroid monolayer cultures. Bile, a critical factor of the intestinal milieu, is required for strain-dependent HuNoV replication. Lack of appropriate histoblood group antigen expression in intestinal cells restricts virus replication, and infectivity is abrogated by inactivation (e.g., irradiation, heating) and serum neutralization. This culture system recapitulates the human intestinal epithelium, permits human host-pathogen studies of previously noncultivable pathogens, and allows the assessment of methods to prevent and treat HuNoV infections.
Human noroviruses are the leading cause of acute gastroenteritis in U.S., probably worldwide

- Responsible for 21 million cases; 70,000 hospitalizations; and 800 deaths annually (CDC estimates)
- $2 billion annually in healthcare and lost productivity costs
- Responsible for >5 million cases of foodborne disease annually
  - Around food-related 15,000 hospitalizations annually [26%, 2
  nd in rank]
  - Around 150 food-related deaths annually [11%, 4
  th in rank]
- Cause of food borne disease of unknown etiology?
Core #3: Epidemiology and Risk Analysis

Person-to-person 78%

- Foodborne 15%
  - Environmental 0.2%
  - Other/Unknown 7%
  - Waterborne <0.1%

- Fecal matter vs. vomitus
- Low infectious dose
- High degree of shedding
- Virus persistence and resistance
- Important venues
Foodborne Transmission

Infected food workers cause about 70% of reported norovirus outbreaks from contaminated food.

Where do norovirus outbreaks from food contamination happen?

- Restaurant | 64%
- Catering or Banquet facility | 17%
- Private Residence | 4%
- Health Care Facilities | 1%
- Schools and Daycare | 1%
- Other/multiple | 13%

Foods Implicated* in Norovirus Outbreaks Reported to CDC by Commodity and Point of Contamination (2001-2008)

*Limited to outbreaks with a simple food (consisting of a single commodity) implicated
**Insufficient or conflicting information provided in outbreak report

Evaluation of a Surface Sampling Method for Recovery of Human Noroviruses Prior to Detection Using Reverse Transcription Quantitative PCR

GRACE TUNG-THOMPSON,1 BLANCA I. ESCUDERO-ABARCA,1,* JANIE OUTLAW,1 ARNAUD GANEE,2 SYLVANIE CASSARD,2 CLAUDE MABILAT,2 AND LEE-ANN JAYKUS1

<table>
<thead>
<tr>
<th>Location</th>
<th>Sampling Location</th>
<th>Number Samples Presumptively Positive/Total Sample Number by Location (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Locations</td>
<td>Baby Changing Station (n=4)</td>
<td>3/8 (37.5%)</td>
</tr>
<tr>
<td>Service Stations</td>
<td>Door Handle (n=58)</td>
<td>3/58 (5.2%)</td>
</tr>
<tr>
<td>Food Service</td>
<td>Flush Handle (n=38)</td>
<td>2/38 (5.3%)</td>
</tr>
<tr>
<td></td>
<td>Sink (n=34)</td>
<td>1/34 (2.9%)</td>
</tr>
<tr>
<td></td>
<td>Toilet Seat (n=66)</td>
<td>0/66 (0%)</td>
</tr>
</tbody>
</table>

Grand Total: 1/4 (25%) 3/58 (5.2%) 7/38 (18.4%) 1/34 (2.9%) 0/66 (0%) 24/200 (12.0%)

Number Samples Presumptively Positive/Total Sample Number by Sample Type (%)

<table>
<thead>
<tr>
<th>Location</th>
<th>Surface</th>
<th>Virus Identity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopping center</td>
<td>Door handle</td>
<td>Norovirus GII.Pe_Gi.L4/Sydney2012</td>
</tr>
<tr>
<td>Shopping center</td>
<td>Flush handle</td>
<td>Norovirus GII.Pe_Gi.L4/San Sebastian</td>
</tr>
<tr>
<td>Grocery store</td>
<td>Door handle</td>
<td>Norovirus GII.Pe_Gi.L4/Sydney2012</td>
</tr>
<tr>
<td>Gas station</td>
<td>Flush handle</td>
<td>Norovirus Hu/Gi.L4/New Taipei</td>
</tr>
<tr>
<td>Movie theater</td>
<td>Door handle</td>
<td>Norovirus GII.Pe_Gi.L4/Sydney2012</td>
</tr>
<tr>
<td>Bank</td>
<td>Sink</td>
<td>Norovirus Hu/Gi.L4/New Taipei</td>
</tr>
</tbody>
</table>
Laboratory Evidence of Norwalk Virus Contamination on the Hands of Infected Individuals

Pengbo Liu, Blanca Escudero, Lee-Ann Jaykus, Julia Montes, Rebecca M. Goulter, Meredith Lichtenstein, Marina Fernandez, Joong-Chul Lee, Elizabeth De Nardo, Amy Kirby, James W. Arbogast, Christine L. Moe

Center for Global Safe Water, Hubert Department of Global Health, Emory University, Atlanta, Georgia, USA; Food Bioprocessing and Nutrition Sciences, North Carolina State University, Raleigh, North Carolina, USA; Gojo Industries Inc., Akron, Ohio, USA
Vomit Splatter

Tung et al., in preparation
Aerosolization of a Human Norovirus Surrogate, Bacteriophage MS2, during Simulated Vomiting

Grace Tung-Thompson1,2, Dominic A. Libera2,3, Kenneth L. Koch1, Francis L. de los Reyes, III1,2,*, Lee-Ann Jaykus1,2

Fig 2. Photo of a Simulated Vomiting Episode. Projectile vomiting of colored simulated vomitus matrix.

Log Concentration

Low Viscosity
Low Titer

Low Viscosity
High Titer

High Viscosity
High Titer

Captured MS2
Vomited

Treatment (mmHg)
# Vomiting as a Symptom and Transmission Risk in Norovirus Illness: Evidence from Human Challenge Studies

Amy E. Kirby*, Ashleigh Streby, Christine L. Moe

Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, GA, United States of America

## Table 3. Norovirus Titers in Emesis.

<table>
<thead>
<tr>
<th>Study</th>
<th># Subjects with Emesis Specimens</th>
<th># Emesis Specimens</th>
<th>% Subjects with ≥ 1 Positive Emesis</th>
<th>% Positive Samples</th>
<th>Sample Mean Titer (GEC&lt;sup&gt;d&lt;/sup&gt;/ml)(SEM&lt;sup&gt;e&lt;/sup&gt;)</th>
<th>Subject Mean Cumulative Shed (GEC&lt;sup&gt;d&lt;/sup&gt;)(SEM&lt;sup&gt;e&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>16</td>
<td>50%</td>
<td>63%</td>
<td>5.8x10&lt;sup&gt;5&lt;/sup&gt; (2.6x10&lt;sup&gt;5&lt;/sup&gt;)</td>
<td>1.3x10&lt;sup&gt;8&lt;/sup&gt; (9.1x10&lt;sup&gt;7&lt;/sup&gt;)</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>20</td>
<td>75%</td>
<td>90%</td>
<td>9.2x10&lt;sup&gt;5&lt;/sup&gt; (3.1x10&lt;sup&gt;5&lt;/sup&gt;)</td>
<td>3.1x10&lt;sup&gt;8&lt;/sup&gt; (1.7x10&lt;sup&gt;8&lt;/sup&gt;)</td>
</tr>
<tr>
<td>All GI</td>
<td>14</td>
<td>36</td>
<td>64%</td>
<td>78%</td>
<td>8.0x10&lt;sup&gt;5&lt;/sup&gt; (2.2x10&lt;sup&gt;5&lt;/sup&gt;)</td>
<td>2.3x10&lt;sup&gt;8&lt;/sup&gt; (1.0x10&lt;sup&gt;8&lt;/sup&gt;)</td>
</tr>
<tr>
<td>3</td>
<td>4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8</td>
<td>25%</td>
<td>38%</td>
<td>1.6x10&lt;sup&gt;5&lt;/sup&gt; (4.5x10&lt;sup&gt;4&lt;/sup&gt;)</td>
<td>1.8x10&lt;sup&gt;7&lt;/sup&gt; (1.8x10&lt;sup&gt;7&lt;/sup&gt;)</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>13</td>
<td>100%</td>
<td>92%</td>
<td>5.0x10&lt;sup&gt;3&lt;/sup&gt; (2.7x10&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>2.3x10&lt;sup&gt;5&lt;/sup&gt; (ND)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Risk Modeling

- NorOPTIMAL (Norovirus On-line Predictive Tool to Investigate Mitigation ALternatives) is a simulation model designed to compare efficacy of different intervention strategies in microenvironments based on health risk and cost.

- Key features of NorOPTIMAL
  - “Agent” based model
  - Probabilistic simulation
  - Inputs informed by research from the collaborative (e.g., transfer rates) and published literature
  - Produces risk metrics include infection probability, disease progression, and outbreak size
Agents interact according to spatial layout and schedule of activities
Core # 4: Prevention & Control

- **Purpose:** Improve understanding the occurrence and behavior of human norovirus in the food safety continuum so as to inform development of scientifically justifiable control measures.

- Activity 4.1: Evaluate and monitor virus occurrence pre- and post-harvest, including alternative microbiological indicators
- Activity 4.2: Develop/evaluate novel antiviral agents for hand and surface disinfection in collaboration with industrial partners
- Activity 4.3: Test efficacy of candidate technologies to remove and/or inactivate viruses and their surrogates in foods (pilot scale)
- Activity 4.4: Move promising processing technologies toward commercialization using stage-gate approach
Virus Persistence

- **Surfaces**
  - Room temperature: Days/weeks

- **Foods and water**
  - Refrigeration: Weeks/months/years
  - Freezing: Months/years

- Also depends on surface/food and virus, RH

- **Transferability**
  - Variable (0.1%->90%)
  - Depends on moisture, surfaces, pressure, virus
  - Sequential (10X)

- **Environmental contamination**
  - Outbreaks
  - Endemic
  - Virus concentrations

- **Persistence and concentration on hands**
- **Airborne?**
- **Relative importance (attribution)**
Inactivation: ‘Traditional’ Methods in Food Processing

- Product relevance?
- Methods
  - Refrigeration and freezing
  - Drying and $a_w$
  - Conventional preservatives
- What about heat?
  - Surrogates differ in heat resistance
  - Norovirus and hepatitis A generally more resistant
Prevention: Surface Disinfection, Direct Contact

- Formulation matters
- Efficacy impacted by concentration and contact time
- Active compounds (ingredients)
  - Chlorine, 1,000-5,000 ppm (+)
  - Benzalkonium chloride chloride (-)
  - Phenols
  - Hypochorous acid, up to 250 ppm
  - Silver dihydrogen citrate
  - Activated hydrogen peroxide
- Emerging technologies
  - Surface coatings (e.g., light activated fluorinated TiO₂)
  - Copper (>70%)
  - Nanoparticle technology

- Soft surfaces?
- Potential drawbacks
Copper as a Self Sanitizing Surface

- Used as antimicrobial since ~2500 BC
- Copper touch surfaces reduce hospital acquired infection rates
- Broadly antimicrobial
  - Efficacy against variety of viruses and bacteria
  - Data lacking for human norovirus

**Hypothesis:** Copper surfaces may be useful to reduce environmentally mediated human norovirus transmission
Destruction of the Capsid and Genome of GII.4 Human Norovirus Occurs during Exposure to Metal Alloys Containing Copper

C. S. Manuel, M. D. Moore, L. A. Jaykus
Department of Food, Bioprocessing, and Nutrition Sciences, North Carolina State University, Raleigh, North Carolina, USA

**FIG 1** Genome and capsid degradation of GII.4 HuNoV during exposure to copper-containing surfaces. Degradation of the GII.4 HuNoV RNA genome and capsid occurs during exposure to copper-containing surfaces. Twenty-five-microliter aliquots of 20% fecal suspensions positive for GII.4 HuNoV were placed onto various alloys at room temperature and eluted at select time points. Sample eluates were analyzed by RT-qPCR without RNase treatment to determine genome integrity (A) and by RT-qPCR following RNase treatment to determine capsid integrity (B). The values in parentheses after each alloy indicate the percentage of copper in the alloy. The drying time was included in the total exposure time and was ~20 to 30 min. The HuNoV RNA copy number was estimated by comparing Ct values to a standard curve. Letters above the bars indicate statistically significant differences (P < 0.05) between alloys for each exposure time. Error bars represent standard errors of the means. All experiments were performed in triplicate.
Electron Microscopy Results

FIG 2  Effect of copper surfaces on the integrity of HuNoV VLPs. One microliter of purified GI1.4 Grimsby HuNoV VLPs (concentration of 1,700 ng/μl) was placed onto copper or stainless steel surfaces and eluted at various time points between 0 and 240 min. Eluted samples were negatively stained with 2% uranyl acetate and visualized by transmission electron microscopy. Bar, 0.1 μm.
What Doesn’t Work

Effect of Grape Seed Extract on Human Norovirus GII.4 and Murine Norovirus 1 in Viral Suspensions, on Stainless Steel Discs, and in Lettuce Wash Water

Dan Li, Leen Baert, Dongsheng Zhang, Ming Xia, Weiming Zhong, Els Van Colliex, Xi Jiang, and Mieke Uyttendaele

The anti-norovirus (anti-NoV) effect of grape seed extract (GSE) was examined by plaque assay for murine norovirus 1 (MNV-1), cell-binding reverse transcription-PCR for human NoV GII.4, and saliva-binding enzyme-linked immunosorbent assay for human NoV GII.4 P particles, with or without the presence of interfering substances (dried milk and lettuce extract). GSE at 0.2 and 2 mg/ml was shown to reduce the infectivity of MNV-1 (>3-log PFU/ml) and the specific binding ability of NoV GII.4 to Caco-2 cells (>1-log genomic copies/ml), as well as of its P particles to salivary human histo-blood group antigen receptors (optical density at 450 nm of >0.8). These effects were decreased as increasing concentrations of dried milk (0.02 and 0.2%) or lettuce extract were added. Under an electron microscope, human NoV GII.4 virus-like particles showed inflation and deformation after treatment with GSE. Under conditions that simulated applications in the food industry, the anti-NoV effect of GSE using MNV-1 as a target organism was shown to be limited in surface disinfection (<1-log PFU/ml, analyzed in accordance with EN 13697:2001). However, a 1.5- to 2-log PFU/ml reduction in MNV-1 infectivity was noted when 2 mg of GSE/ml was used to sanitize water in the washing bath of fresh-cut lettuce, and this occurred regardless of the chemical oxygen demand (0 to 1,500 mg/ml) of the processing water.
Prevention: Surface Disinfection, Indirect Contact (Fogging)

- Broad spatial coverage
- Potential drawbacks
- Application approach and concentration matter
- Active ingredients
  - Hydrogen peroxide
  - ClO₂
  - Others?
- Application to clean-up after vomiting event or reservoir locations like restrooms?
- Soft surfaces?
Hand Sanitizers

- Product type [actives]
  - Alcohol [60-90%, ethanol, isopropanol, n-propanol] (-)
  - *Povidone-iodine* (+/-)
  - Benzalkonium chloride chloride (-)
  - Triclosan (-)
  - Chlorhexidine (-)
  - “Sanitwice”?
  - *Emerging actives*
    - Copper
    - *Bismuth subsalicylate*
    - Others?

- Formulation matters
- Product application (volume and time)
- Validation/methodological issues
- Regulatory/licensing/use issues
ASTM E-1838-02 (Fingerpad Method)

American Standard Test Method for in vivo evaluation of the activity of handwash agents using the fingerpad (ASTM E 1838-02)

Study procedures:
- Virus dried
- Elute virus from fingerpads
Norovirus Strain-Specific Ethanol Sensitivity

RESEARCH ARTICLE

Strain-Specific Virolysis Patterns of Human Noroviruses in Response to Alcohols

Geun Woo Park1, Nikal Collins1,2, Leslie Barclay1, Liya Hu2, B. V. Venkata Ram Prasad3, Benjamin A. Lopman1, Jen Viré1

1 Division of Viral Diseases, Centers for Disease Control and Prevention, Atlanta, GA, United States of America, 2 Atlanta Research and Education Foundation (AREF), Atlanta, GA, United States of America, 3 Verna Mims McLean Department of Biochemistry and Molecular Biology, Baylor College of Medicine, Houston, TX, United States of America

Table 2. Virolysis patterns of GII norovirus strains after exposure to ethanol and isopropanol.

<table>
<thead>
<tr>
<th>Genogroup</th>
<th>Strain ID</th>
<th>Genotype</th>
<th>50% Ethanol</th>
<th>70% Ethanol</th>
<th>90% Ethanol</th>
<th>50% Isopropanol</th>
<th>70% Isopropanol</th>
<th>90% Isopropanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>GII</td>
<td>2010746610</td>
<td>GII.1</td>
<td>0.2 ± 0.1</td>
<td>0.3 ± 0.2</td>
<td>0.7 ± 0.3</td>
<td>0.1 ± 0.1</td>
<td>0.1 ± 0.1</td>
<td>0.4 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>2010746618</td>
<td>GII.2</td>
<td>0.4 ± 0.2</td>
<td>0.4 ± 0.2</td>
<td>0.7 ± 0.1</td>
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<td>0.2 ± 0.2</td>
<td>0.3 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>2013775428</td>
<td>GII.43</td>
<td>2.3 ± 0.2</td>
<td>2.3 ± 0.3</td>
<td>2.4 ± 1.1</td>
<td>2.0 ± 0.5</td>
<td>1.4 ± 0.3</td>
<td>2.4 ± 0.1</td>
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<tr>
<td></td>
<td>2013775418</td>
<td>GII.43</td>
<td>1.2 ± 0.5</td>
<td>2.5 ± 0.5</td>
<td>2.7 ± 0.4</td>
<td>1.4 ± 0.3</td>
<td>0.9 ± 0.3</td>
<td>1.5 ± 0.4</td>
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<tr>
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<td>2010746350</td>
<td>GII.44</td>
<td>0.4 ± 0.1</td>
<td>0.5 ± 0.2</td>
<td>1.4 ± 0.3</td>
<td>0.4 ± 0.1</td>
<td>1.0 ± 0.5</td>
<td>2.4 ± 0.4</td>
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<tr>
<td></td>
<td>2010746173</td>
<td>GII.44</td>
<td>0.2 ± 0.1</td>
<td>0.5 ± 0.4</td>
<td>0.9 ± 0.1</td>
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<td>1.0 ± 0.3</td>
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<td>20107465262</td>
<td>GII.44</td>
<td>0.4 ± 0.2</td>
<td>0.4 ± 0.2</td>
<td>1.6 ± 0.3</td>
<td>0.5 ± 0.2</td>
<td>0.5 ± 0.1</td>
<td>1.5 ± 0.1</td>
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<tr>
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<td>2013775232</td>
<td>GII.44</td>
<td>2.0 ± 0.3</td>
<td>2.1 ± 0.1</td>
<td>2.2 ± 0.1</td>
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<td>2.1 ± 0.6</td>
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<tr>
<td></td>
<td>2013751795</td>
<td>GII.45</td>
<td>1.1 ± 0.2</td>
<td>2.2 ± 0.5</td>
<td>1.6 ± 0.2</td>
<td>1.0 ± 0.2</td>
<td>0.5 ± 0.3</td>
<td>0.9 ± 0.3</td>
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<tr>
<td></td>
<td>2013843445</td>
<td>GII.45</td>
<td>1.8 ± 0.8</td>
<td>1.9 ± 0.7</td>
<td>2.4 ± 0.2</td>
<td>1.1 ± 0.3</td>
<td>0.4 ± 0.3</td>
<td>1.8 ± 0.2</td>
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<tr>
<td></td>
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<td>GII.45</td>
<td>2.5 ± 0.4</td>
<td>3.0 ± 0.2</td>
<td>3.1 ± 0.3</td>
<td>1.8 ± 0.3</td>
<td>1.7 ± 0.3</td>
<td>0.8 ± 0.8</td>
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<tr>
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<td>2010746154</td>
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<td>0.1 ± 0.0</td>
<td>0.4 ± 0.1</td>
<td>0.7 ± 0.1</td>
<td>0.1 ± 0.1</td>
<td>0.1 ± 0.1</td>
<td>0.8 ± 0.8</td>
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<tr>
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<td>2012706250</td>
<td>GII.12</td>
<td>0.0 ± 0.1</td>
<td>0.1 ± 0.1</td>
<td>0.7 ± 0.1</td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
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<tr>
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<td>GII.12</td>
<td>0.0 ± 0.1</td>
<td>0.1 ± 0.1</td>
<td>0.7 ± 0.1</td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
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<td>GII.12</td>
<td>0.3 ± 0.3</td>
<td>1.4 ± 0.1</td>
<td>1.6 ± 0.1</td>
<td>0.2 ± 0.1</td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
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<tr>
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<td>2010746174</td>
<td>GII.13</td>
<td>0.3 ± 0.1</td>
<td>0.4 ± 0.1</td>
<td>0.2 ± 0.2</td>
<td>0.5 ± 0.2</td>
<td>0.5 ± 0.4</td>
<td>0.0 ± 0.2</td>
</tr>
</tbody>
</table>

Average reduction: 0.9 ± 0.5 | 1.2 ± 1.1 | 1.4 ± 0.9 | 0.6 ± 0.7 | 0.3 ± 0.4 | 1.0 ± 0.8
Core #5: Extension and Outreach

Gaps in Food Safety Professionals’ Knowledge about Noroviruses

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Consumer Education Needed on Norovirus Prevention and Control: Findings from a Nationally Representative Survey of U.S. Adults

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Prevention: Extension and Outreach

- **Audiences**
  - Fresh produce
  - Shellfish
  - Retail (food handlers)
  - Consumers
  - Public health officials

- **Methods**
  - Curricula
  - Training programs
  - Written materials

- **Issues**
  - Resources
  - Evaluation
  - Compliance
  - Sustained behavior change
Core 5: Extension and Outreach

- Fresh Produce Industry
  - Contributions to national GAPs training curriculum

- Molluscan Shellfish Industry (ISSC)
  - Contributions to national harvester/dealer training curriculum
  - Educational video
  - Recreational boaters

- Food Service/Grocery Industries
  - Environmental sampling
  - Vomit/fecal matter clean-up guidelines

- Sanitation and Hygiene Industry (including CLIA)
  - Testing candidate technologies
Core 6: Capacity Building

- Website
- Comprehensive reagent/protocol exchange
  - VLPs, glycans, reverse genetics systems
  - CDC “Platinum Panel”
- Literature database
  - Freely accessible papers to collaborators (n>3,000)
  - Freely accessible abstracts on Web
- Discretionary funding
- Student training
  - Undergrad: 11 (NCSU, Clemson, BCM, Emory, UGA, OSU, IIT)
  - Grad: 12 (BCM, Emory, OSU, Rutgers, Clemson, U-DE, NCCU, GSU, UGA, NCSU)
Educational Visuals
Hand-Washing
Lynette's Norovirus Nightmare

The Norovirus Nightmare began early in the week. The symptoms were a dozens.

Imagine you as the one who is working to keep everyone happy and healthy...

Thus, our family members were subjected to a Norovirus nightmare...

That's our latest Norovirus Nightmare from Dr. Lynette Johnsen of our Admin Team, which puts Quality Family Time in perspective.

Thanks to an unexpected family event, we had to come up with a creative solution to the problem. With the help of our team and their ideas, we were able to create a Norovirus-themed family event.

Here's our story:

The 12 Days of Norovirus

1. Start of norovirus
2. Norovirus family
3. Norovirus symptoms
4. Norovirus family at home
5. Norovirus family at work
6. Norovirus family at play
7. Norovirus family at the beach
8. Norovirus family at the movies
9. Norovirus family at the restaurant
10. Norovirus family at the mall
11. Norovirus family at the airport
12. Norovirus family at home, happy and healthy again

Morgan's Norovirus Nightmare

Two great stories about our Norovirus nightmare, and the one that shows how norovirus can mean fun for the whole family!

Name: Morgan Cho
Institution: Clemson University
Position: Graduate Student in Food, Nutrition, and Packaging Sciences

Please describe a time you believed you had norovirus:

It was a night... Just like this...

Well, actually, it was one day early February, 2018. My family had planned for a family weekend. My sister, along with her mom, her husband, and their children were traveling throughout the state in the days before our return home. Our visit was brief... at first.

On Saturday, we were all eating lunch when one of the kids experienced a similar reaction as us, but at a slower pace. Bells were being rung, our little things didn’t seem to go wrong. We had a lot of fun cleaning up, but our mom was the first to notice that something was wrong. Her dishwashing powdered some cleaning solution and washed it all over the sink. I remember it clearly, the scent of the sink as we all tried to brush the sink or put it away to be cleaned.

The Traveling Microbiologist
Summary of Achievements

- Cell culture model!
- Comprehensive surrogate comparison, Tulane probably most relevant
- Detection
  - Lots of ligands with broader reactivity
  - Microarrays for genotyping
  - Better understanding of infectivity dilemma
- Key epidemiological findings
  - Improved understanding of disease burden
  - Role of fresh produce and “complex” foods
  - Importance of food handler
  - Children/elderly
- Aerosolization of virus during vomiting
- Prototype risk model
Summary of Achievements

- Food processing
  - Resistance to most commonly used food processes
  - Perhaps more heat resistant than previously thought
  - Novel processes of promise
  - What does not work
  - Hurdle approach?

- Sanitizers and disinfectants
  - None result in complete inactivation at normal use recommendations
  - High concentrations and long contact times necessary, particularly on surfaces
  - Copper may be promising
Lessons Learned

- Cross disciplinary, holistic approach
- Share the wealth
- Team-building is critical
- Time commitment by leadership
- Budget for support staff
- Money makes things happen!
- Inevitable administrative hurdles
- Listen to stakeholders
- Evaluation is a challenge!
- Others.....
Follow our progress...

NoroCORE
Food Virology

Collaborative for Outreach, Research & Education

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