

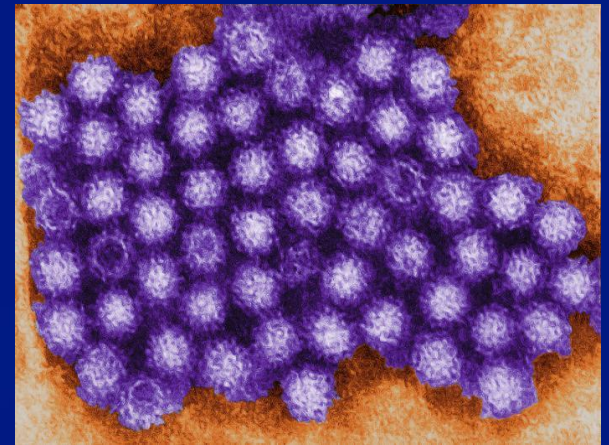
# Norovirus Epidemiology and Food Safety

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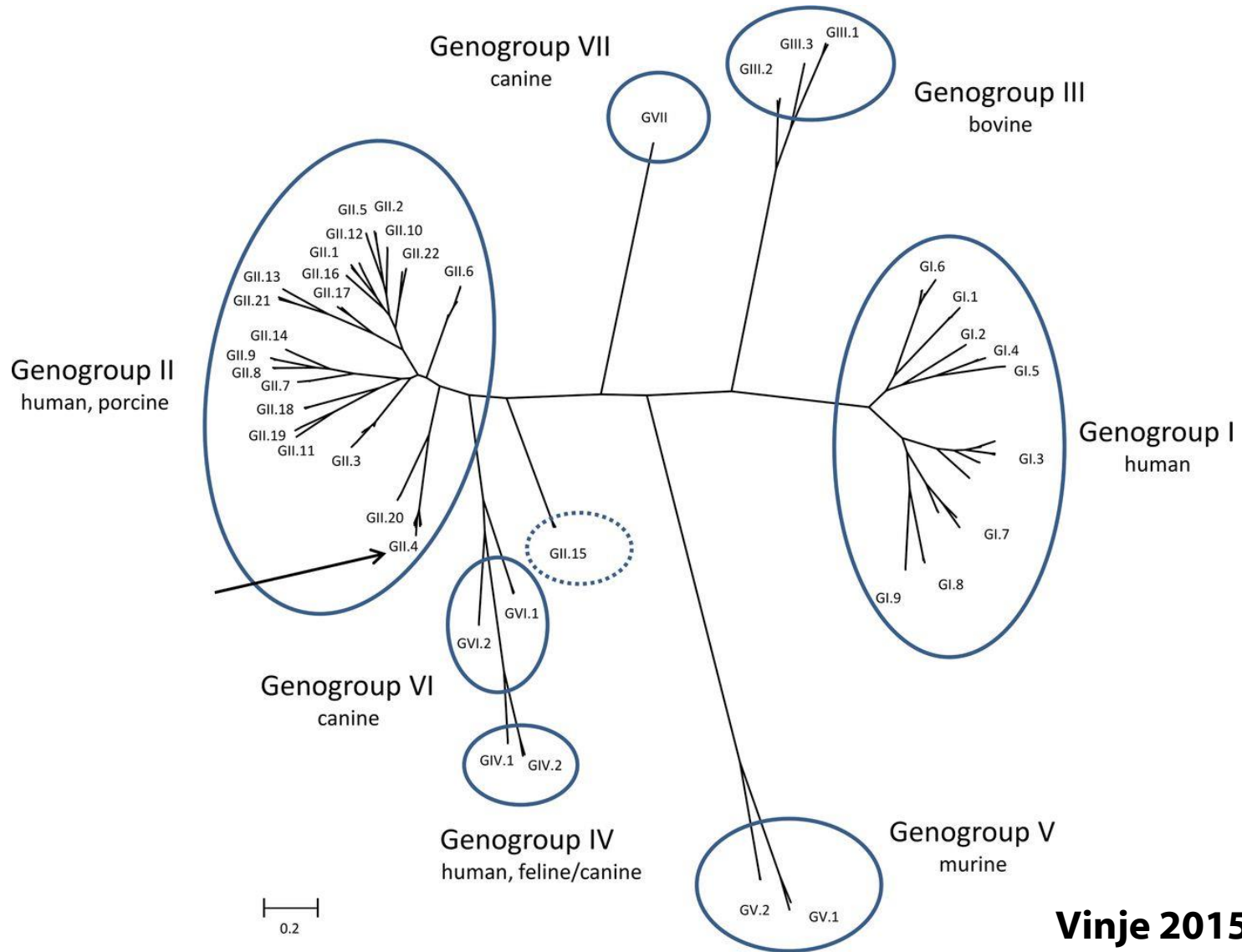
*FDA Central Region Retail Food Protection Seminar, Milwaukee, WI  
August 31, 2016*

# Noroviruses: The Perfect Human Pathogens?

- **Highly contagious**
- **Rapidly and prolifically shed**
- **Diverse and constantly evolving**
- **Evoking limited immunity**
- **Moderately virulent**



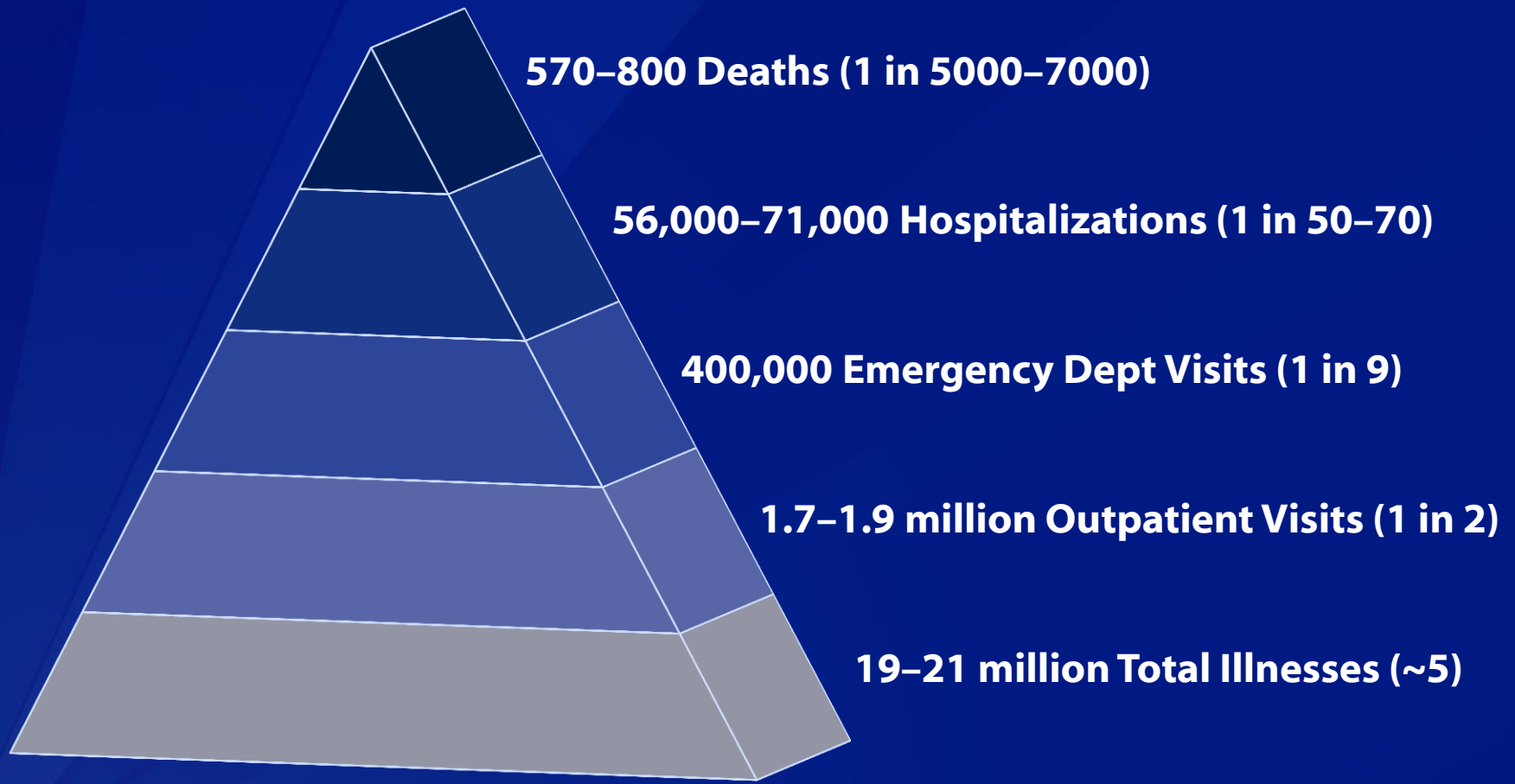
# Classification of Noroviruses



# Emergent GII.4 Norovirus Strains

Norovirus Strain	Years of Circulation	Increased Number of US Outbreaks
Bristol	1987–1994	None
<b>95/96-US</b>	<b>1995–2002</b>	<b>1995–1996</b>
Henry	2000–2002	None
<b>Farmington Hills</b>	<b>2002–2004</b>	<b>2002–2003</b>
Hunter	2003–2006	None
Asia	2004–2006	None
<b>Yerseke</b>	<b>2006–2008</b>	<b>2006–2007</b>
Osaka	2005–2007	None
<b>Den Haag</b>	<b>2006–2009</b>	<b>2006–2007</b>
New Orleans	2009–present	None
Sydney	2012–present	None

# Annual Burden (Lifetime Risk) of Norovirus Disease in the United States



# **Burden of Foodborne Norovirus in the United States**

- **Causes 58% of all domestically-acquired foodborne illness from known agents**
  - **#1 cause of illness**
  - **#2 cause of hospitalization**
  - **#4 cause of death**
- **Costs \$2 billion per year in medical care services and lost productivity**



# Global Burden of Norovirus

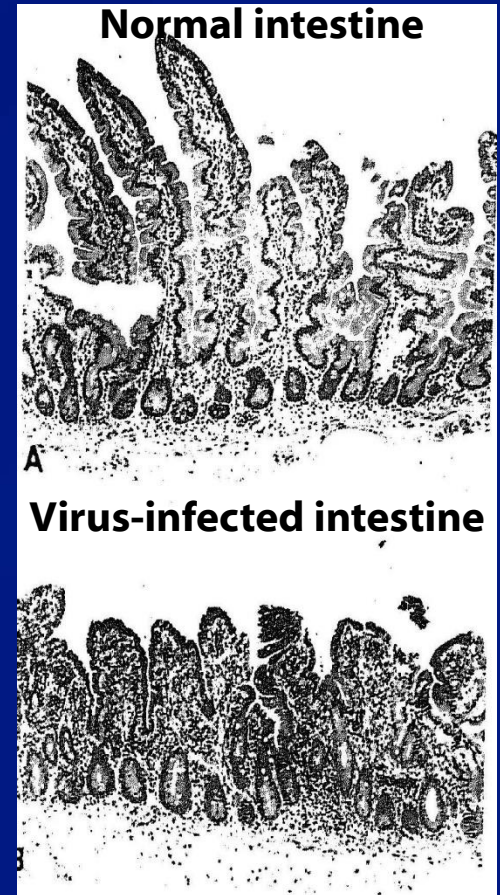
- **WHO Foodborne Disease Burden Epidemiology Reference Group (FERG)**
- **Global and regional age-stratified estimates of illnesses, deaths, and DALYs**
- **Norovirus ranking as foodborne hazard:**
  - #1 cause of foodborne illness
  - #4 cause of foodborne deaths
  - #5 cause of foodborne DALYs
- **Total norovirus burden annually:**
  - 685 million cases; 200 million in children <5
  - 212,489 deaths; 54,214 in children <5
  - 85% of illnesses and 99% of deaths occur in developing countries
  - \$60 billion in direct health system costs and productivity losses



**Pires 2015 PLoS One**  
**Kirk 2015 PLoS Med**  
**Bartsch 2016 PLoS One**  
**Hall 2016 Exp Rev Vac**

# Clinical Disease

- **Incubation period: 12-48 hours**
- **Acute-onset vomiting and/or diarrhea**
  - Watery, non-bloody stools
  - Abdominal cramps, nausea, low-grade fever
- **Most recover after 12-72 hours**
  - ~10% seek medical attention; some require hospitalization and fluid therapy
  - More severe disease in elderly, young children, and immune compromised
- **30% of infections are asymptomatic**

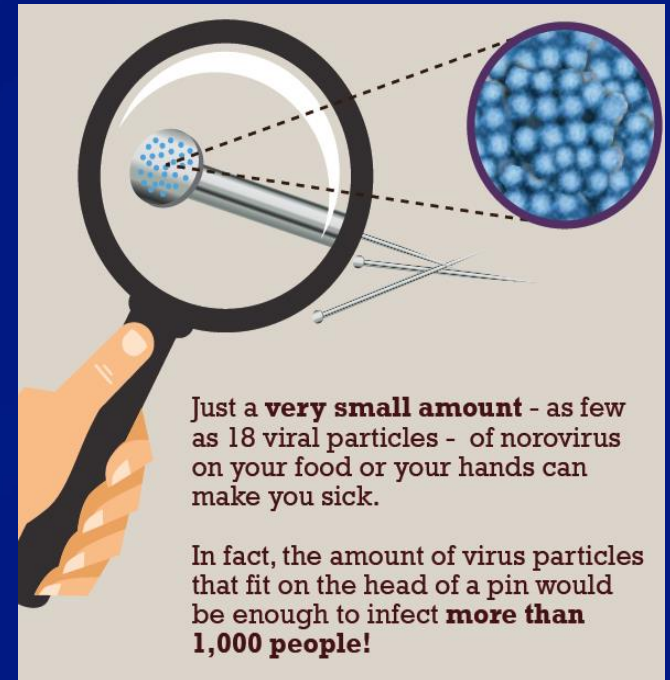


**de Wit 2001 AJE**  
**Phillips 2010 AJE**  
**Hall 2011 EID**



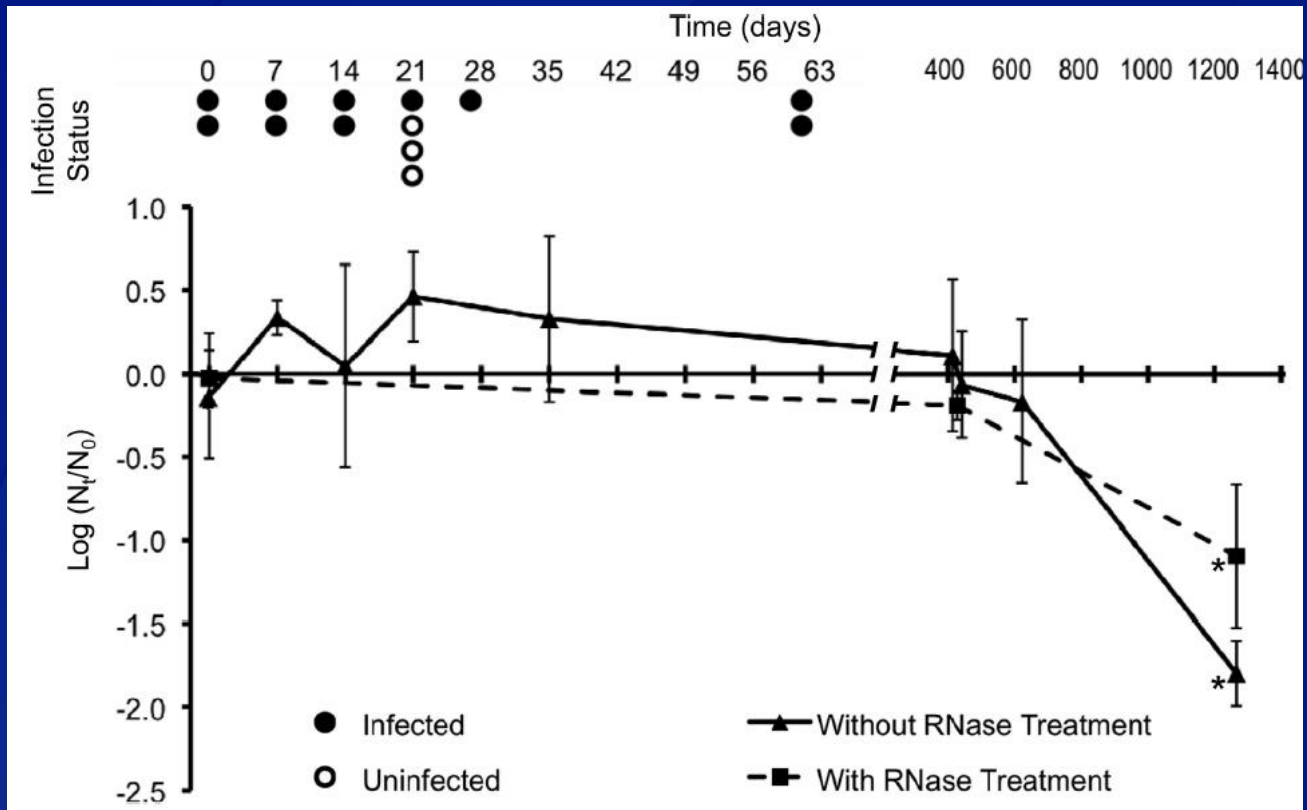
# Viral Shedding

- Primarily in stool, but also vomitus
- Occurs for at least 2-3 weeks
- Peaks 4 days after exposure
  - $10^5$ - $10^{11}$  viral copies/gram feces
  - May persist after resolution of symptoms
- Infectious dose: 18-2,800 viral particles
- Infectivity of prolonged viral shedding and role in transmission is unknown



**Atmar 2008 EID**  
**Aoki 2010 J Hosp Infect**  
**Teunis 2008 J Med Virol**  
**Atmar 2014 JID**

# Infectivity and Persistence



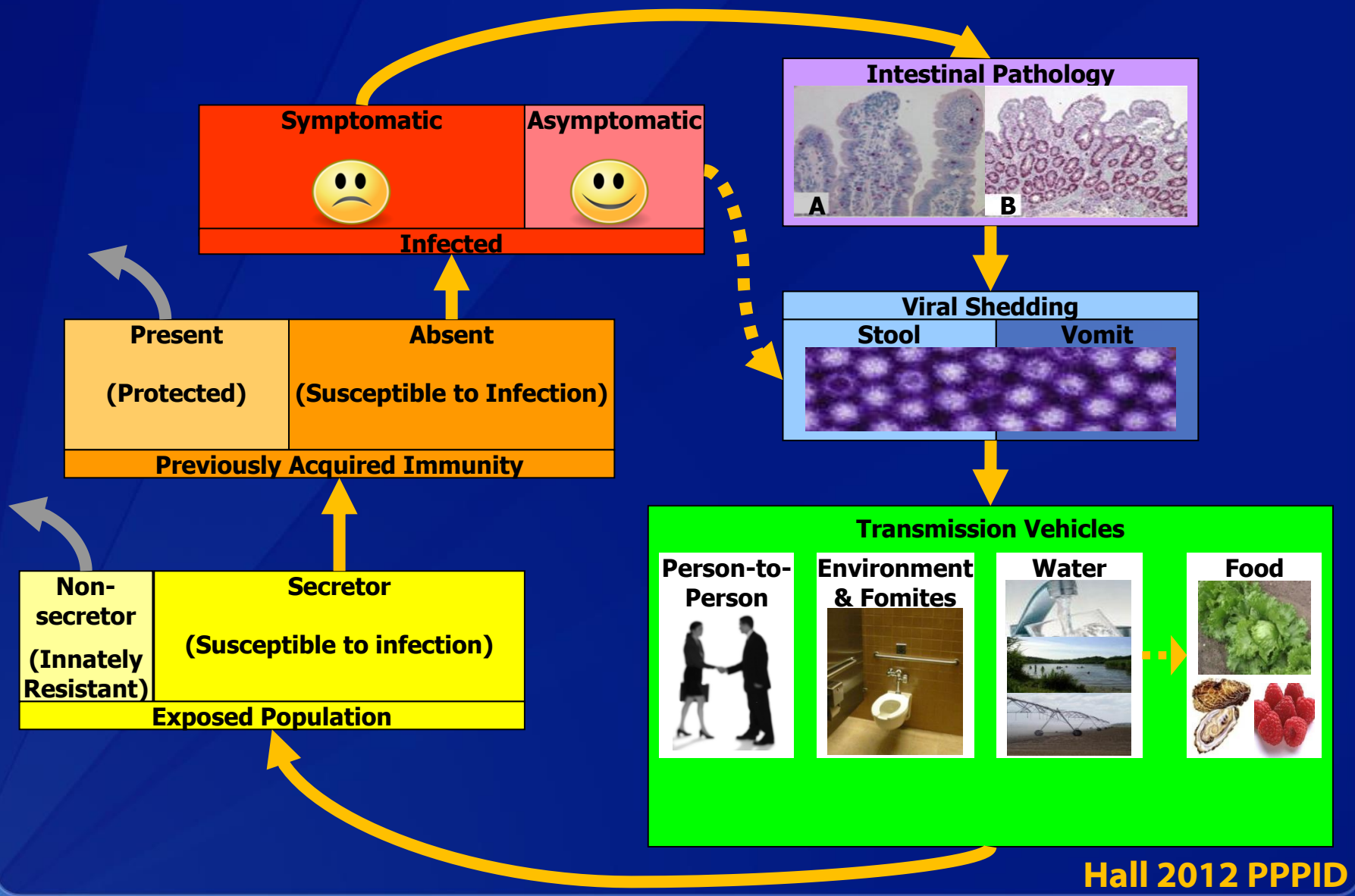
- **Norovirus can remain infectious for  $\geq 61$  days and detectable for  $>3$  years in groundwater**

# Immunity and Genetic Susceptibility

- **Human volunteer studies demonstrated short-term homologous immunity (6–24 months)**
- **Mathematical modeling based on observed disease incidence suggests longer duration (4–8 years)**
- **Degree of cross-protection unclear**
- **Genetic correlates of susceptibility/resistance**
  - **Histo-blood group antigens**
  - **Secretor status (FUT2 gene)**

**Parrino 1977 NEJM**  
**Johnson 1990 JID**  
**Simmons 2013 EID**  
**Lindesmith 2003 Nat Med**

# Norovirus Transmission Cycle

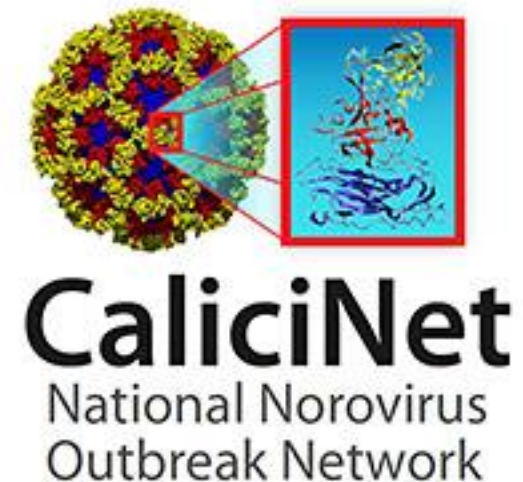


# U.S. Norovirus Outbreak Surveillance

- **NORS**
  - Epidemiologic surveillance for all enteric disease outbreaks
  - Data on setting, transmission mode, exposures, demographics, outcomes
- **CaliciNet**
  - Laboratory surveillance using molecular genotyping of outbreak-associated specimens
  - Data on genotypes to identify new strains and potentially link outbreaks



**NORS**  
National Outbreak  
Reporting System

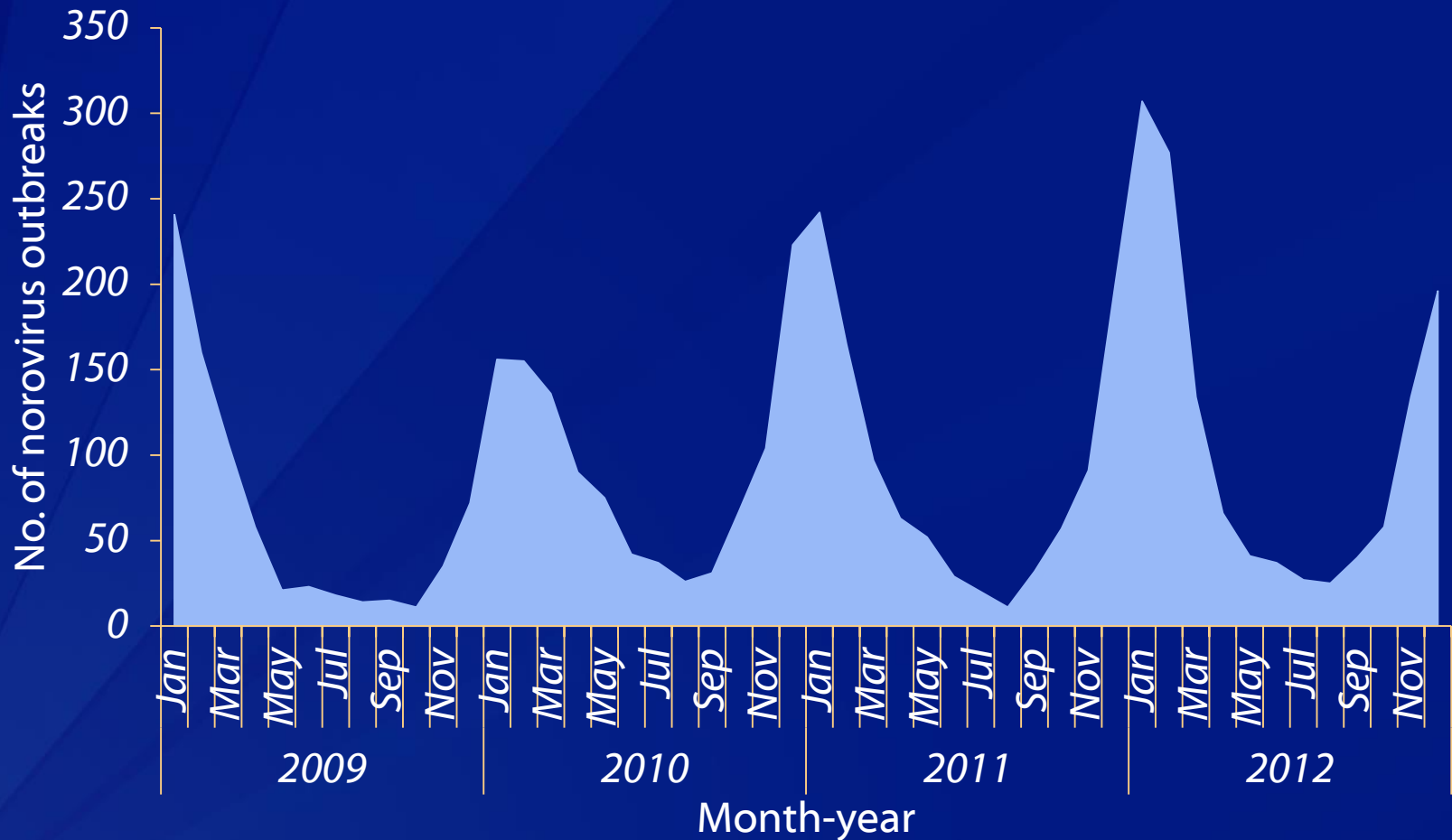
The logo for NORS (National Outbreak Reporting System) features the word "NORS" in a large, blue, sans-serif font. To the right of the text is a cluster of five hexagons in yellow, light green, dark green, blue, and maroon. Below the text, the words "National Outbreak Reporting System" are written in a smaller, grey, sans-serif font.

**CaliciNet**  
National Norovirus  
Outbreak Network

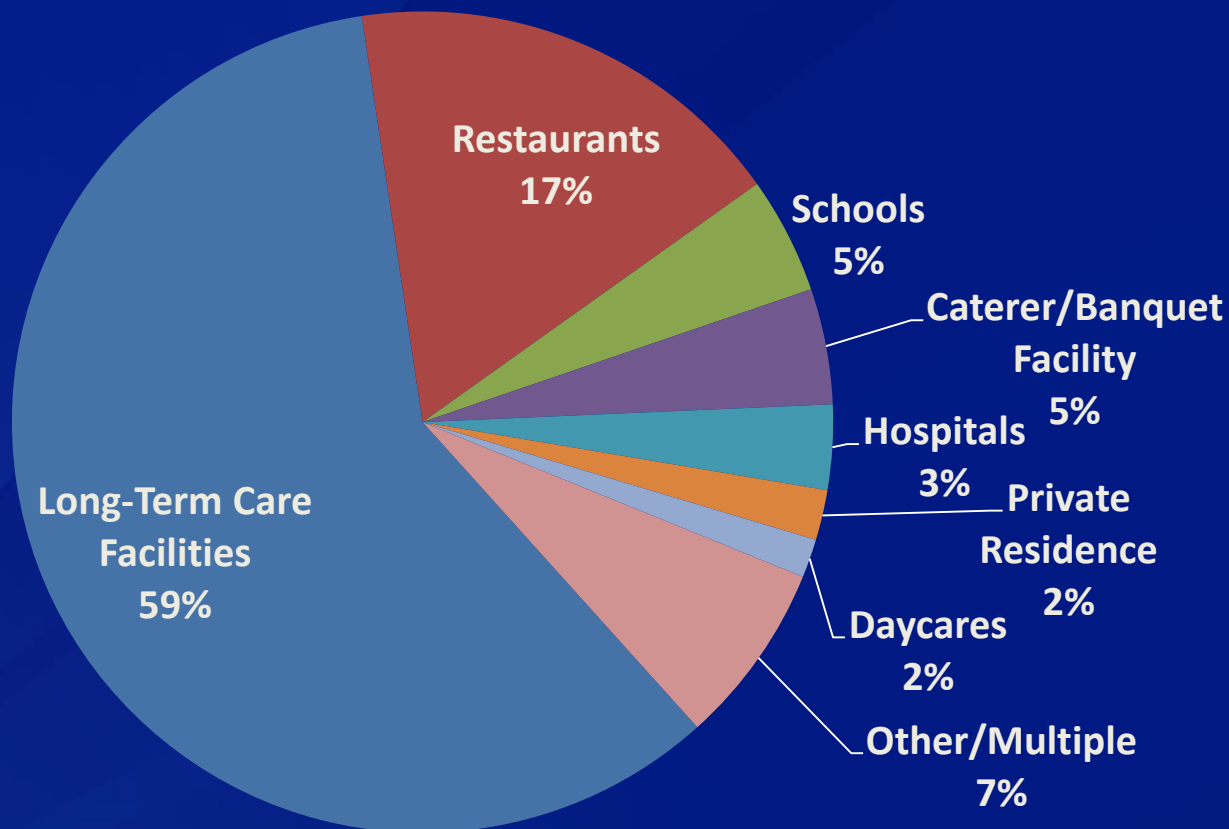
The logo for CaliciNet (National Norovirus Outbreak Network) features a circular, multi-colored virus particle on the left. A red-bordered rectangular inset on the right shows a detailed 3D molecular structure of a virus particle. Below the image, the word "CaliciNet" is written in a large, bold, black, sans-serif font. Underneath that, the words "National Norovirus Outbreak Network" are written in a smaller, black, sans-serif font.



# Norovirus Outbreaks by Month, NORS, 2009-2012 (N=4,318)

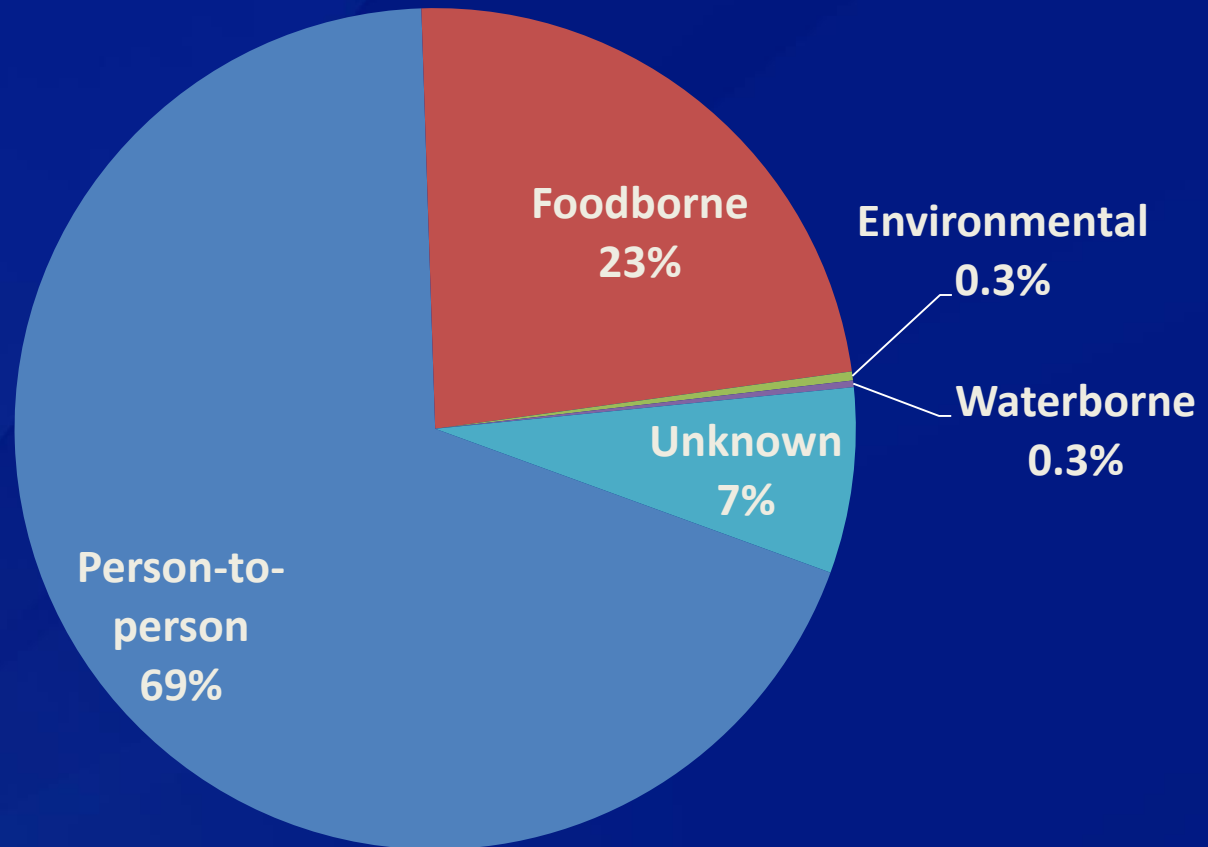


# Setting of Norovirus Outbreaks, NORs, 2009-2012 (N=3,243)



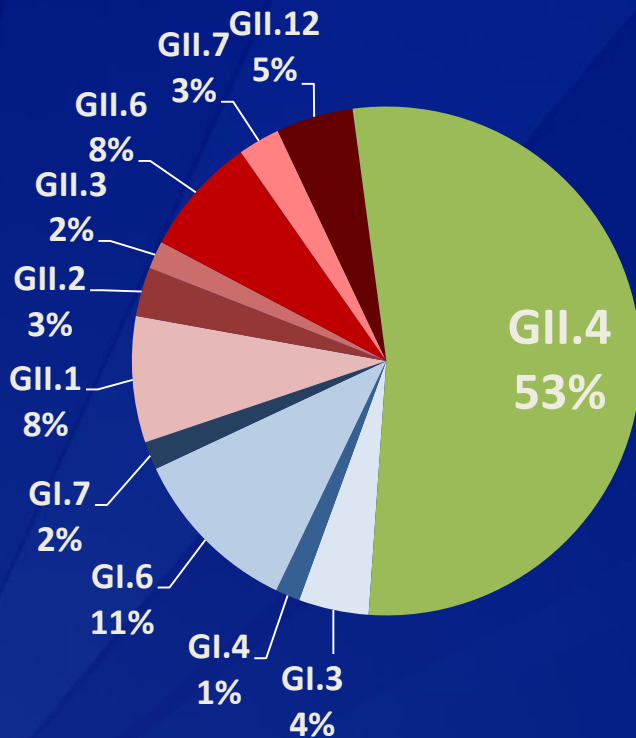
**Note: Does not include 44 (1%) norovirus outbreaks meeting VSP posting criteria**

# Transmission Mode of Norovirus Outbreaks, NORS, 2009-2012 (N=4,318)

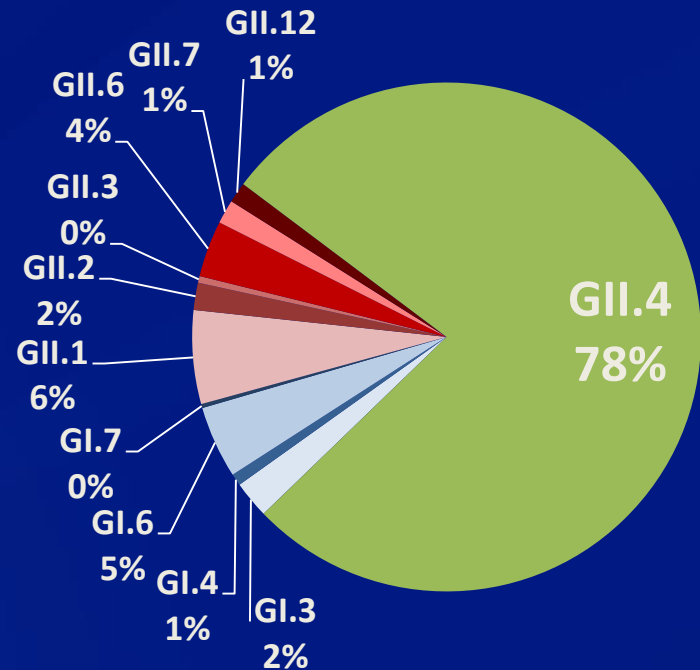


# Norovirus Genotype Distribution by Transmission Route, CaliciNet, 2009-2013

Foodborne Outbreaks (n=449)



Person-to-Person Outbreaks (n=2371)



Non-GII.4 genotypes 3x more likely to be foodborne

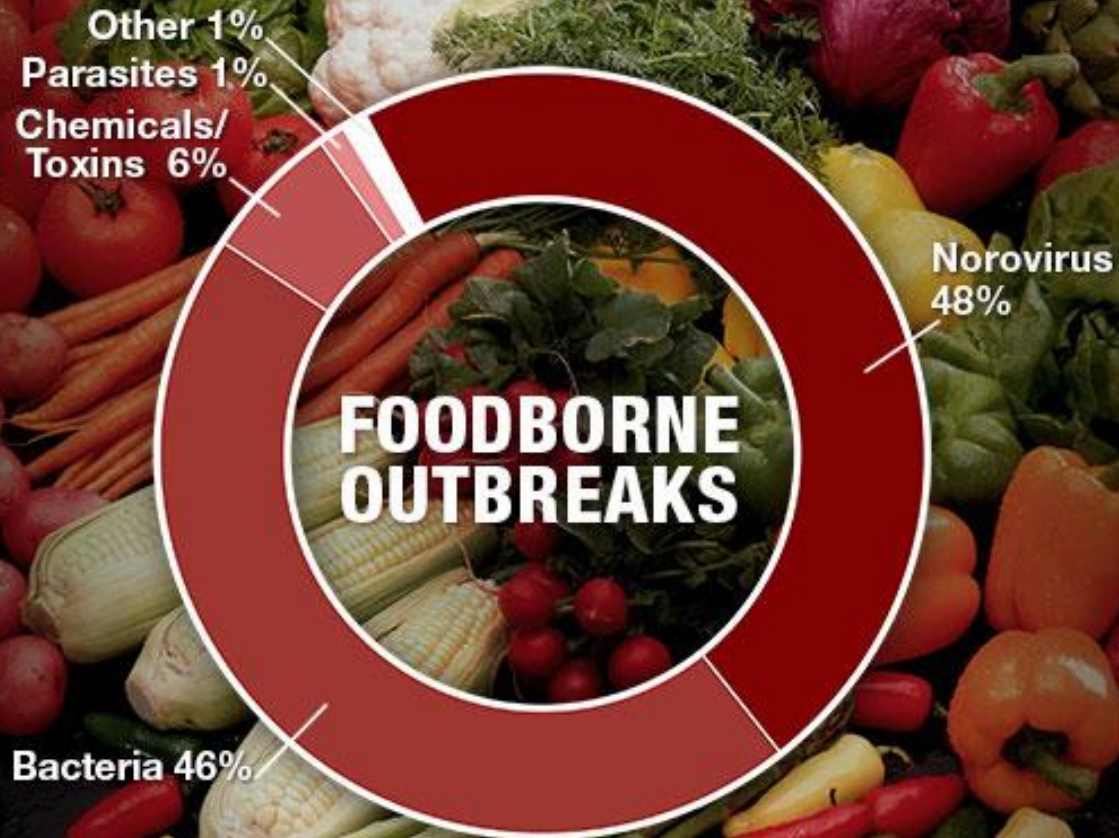
# Predominant Epidemiologic Characteristics of Norovirus Outbreaks by Genotype

Characteristic	GII.4	Non-GII.4
Seasonality	Winter	Spring-summer or non-seasonal
Setting	Healthcare facilities	Non-health care (restaurants, schools, etc.)
Transmission	Person-to-person	Foodborne
Ages affected	≥65 years	<65 years
Severity	Elevated rates of hospitalization and death	Lower rates of severe outcomes

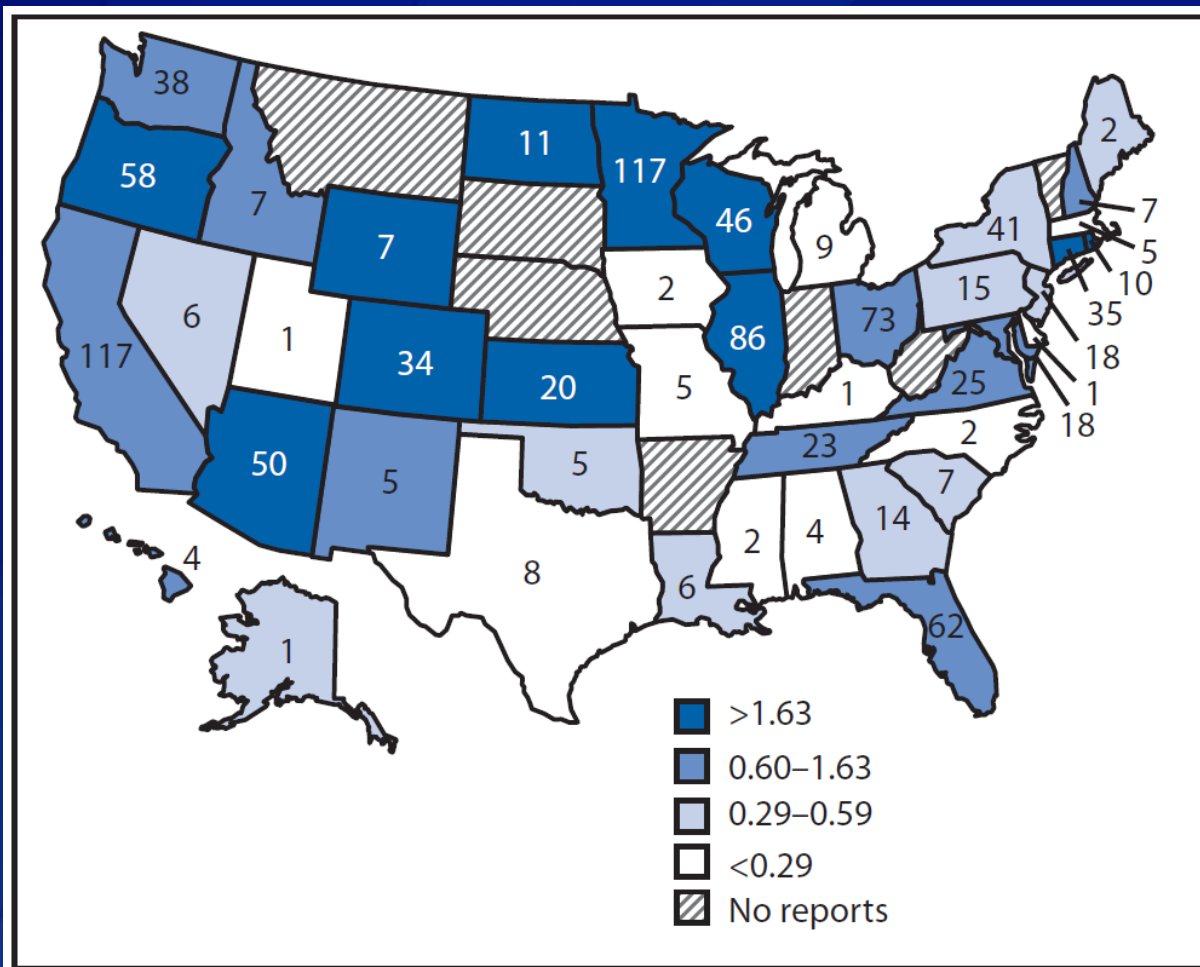
**Vega 2014 JCM**  
**Leshem 2013 EID**  
**Desai 2012 CID**  
**Matthews E&I 2012**



# SINGLE KNOWN CAUSES OF FOODBORNE ILLNESS OUTBREAKS, U.S., 2009-2012



# Foodborne Norovirus Outbreaks by State, NORS, 2009–2012

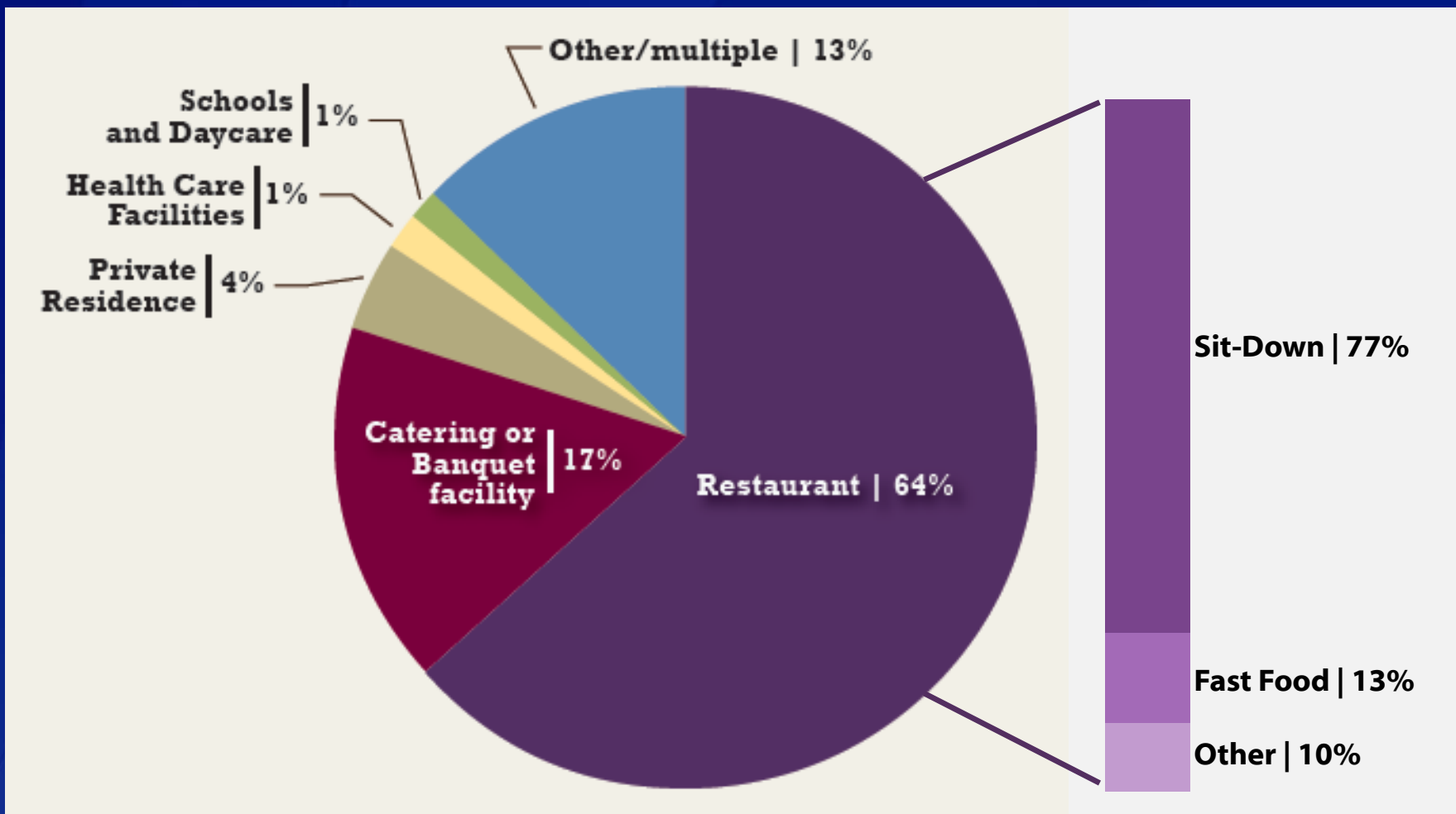


- 1,008 outbreaks reported by 43 states
- Median outbreaks per state: 9 (range 1–117)
- Median reporting rate per million person-years: 0.6 (range 0.05–5.5)

\* Legend indicates rate ranges divided by quartile.

Hall 2014 MMWR

# Settings of Foodborne Norovirus Outbreaks, NORS, 2009–2012



# Contributing Factors and Foods Implicated in Foodborne Norovirus Outbreaks, NORs, 2009–2012

- **Factors contributing to contamination reported in 520 (52%) outbreaks**
  - **70% implicated infectious food worker as source**
    - 54% involved bare-hand contact with ready-to-eat foods
- **Specific food item in 324 (32%) outbreaks**
  - **92% implicated foods contaminated during final preparation; 75% were foods eaten raw**
  - **Single food category identified in only 21%**
    - Vegetable row crops (30%)
    - Fruits (21%),
    - Mollusks (19%)



# **Environmental Health Specialists Network (EHS-Net) Studies on Restaurant Food Safety**

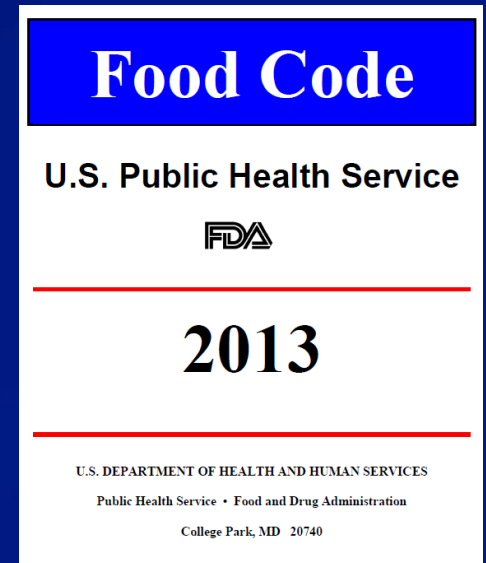
- **Ill food worker study**
  - 1 in 5 food workers report working while sick with diarrhea and vomiting
  - Significant factors in their decision were fear of job loss and concerns about leaving coworkers short staffed
- **Hand hygiene study**
  - Food workers practice proper hand hygiene only 27% of for which recommended
  - Less frequently (16%) when gloves were used

**Carpenter 2013 JFP  
Green 2006 JFP**

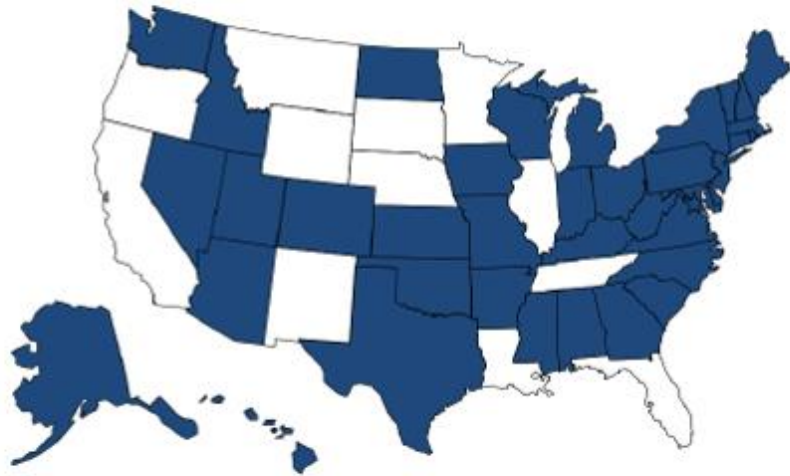


# Assessment of State Food Safety Regulations for Norovirus Prevention

- **Key norovirus recommendations for food service industry in 2013 FDA Food Code**
  - Adoption of specific provisions at discretion of state and local governments
  - Detailed adoption not previously tracked by any federal agency
- **Analyzed food codes of 50 states, DC, and Puerto Rico for 5 specific provisions:**
  1. **Require hand washing**
  2. **Prohibit bare-hand contact with RTE food**
  3. **Exclude ill staff until  $\geq 24$  hours after asymptomatic**
  4. **Require certified food protection manager**
  5. **Response plan to contamination events**



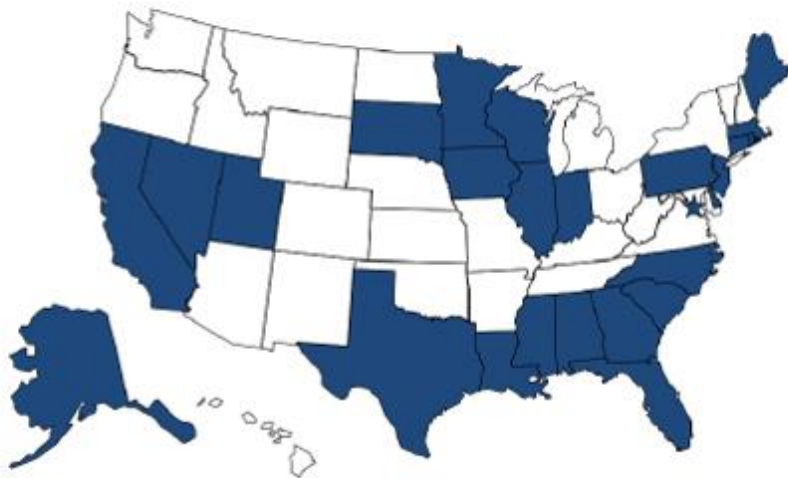
**Prohibition of bare-hand contact**



**Exclusion of food workers with vomiting/diarrhea**



**Certified Food Protection Manager**

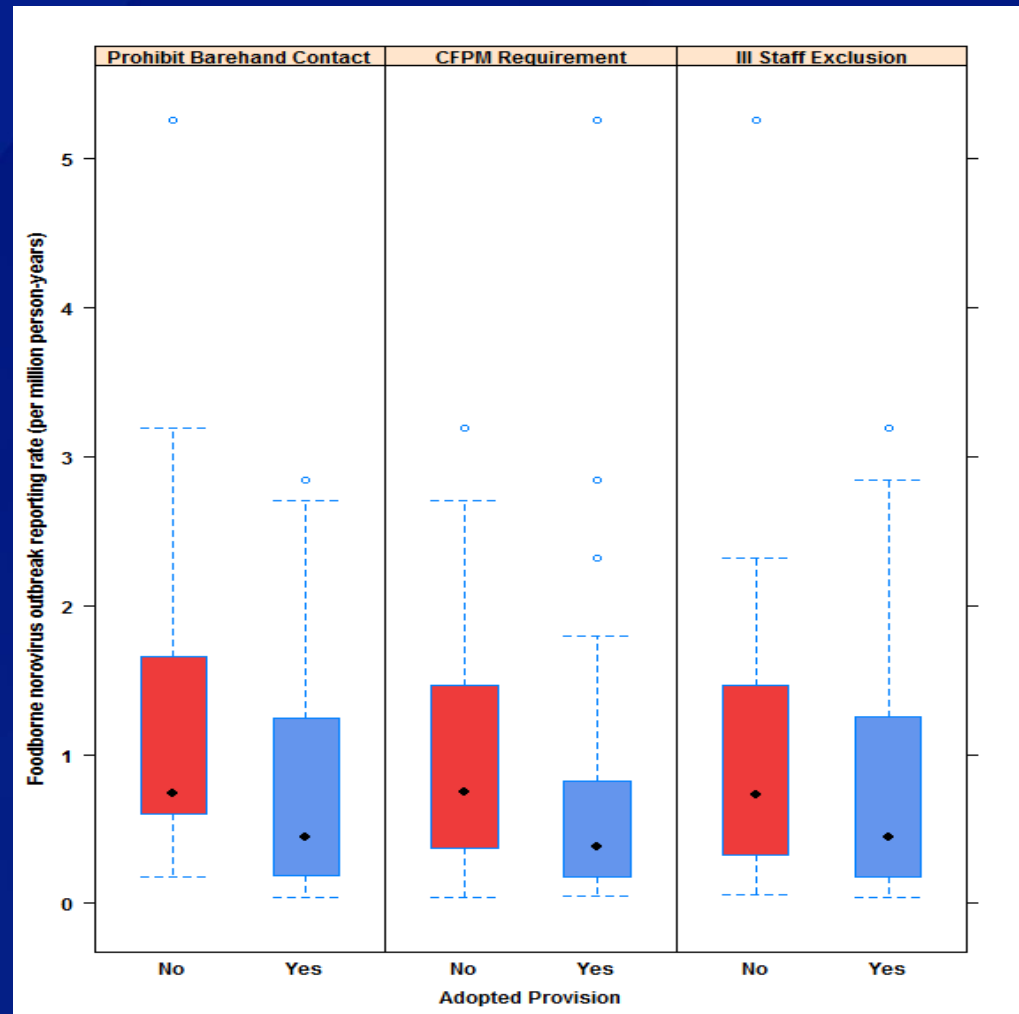


**Contamination event response plan**



# Rate of Reported Foodborne Norovirus Outbreaks Among States Adopting Provisions

- Lower rates of reported outbreaks in states that adopted these provisions
- Suggests potential impact of adoption on reducing incidence of foodborne norovirus
- Many potential confounders and limitations of outbreak surveillance data



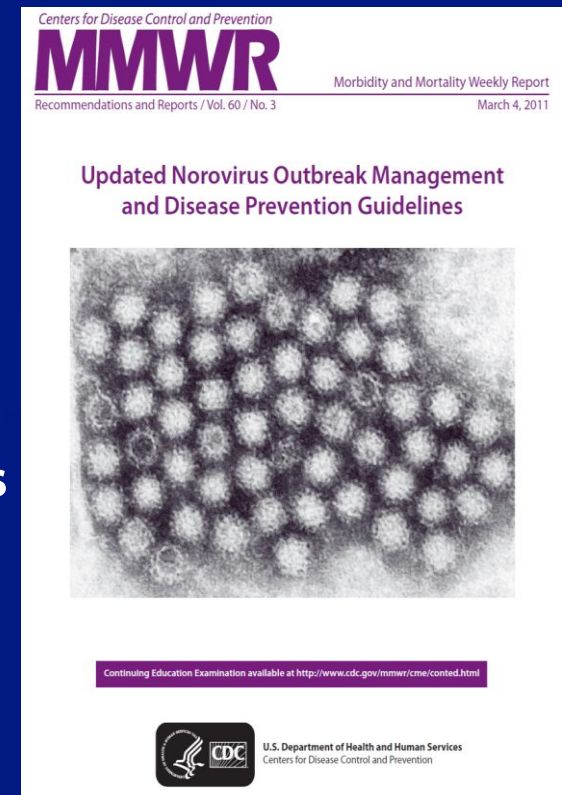
# Conclusions and Public Health Implications

- **Noroviruses are the leading cause of reported foodborne disease outbreaks in the United States**
- **Infected food workers are the most common source of foodborne norovirus outbreaks, often by touching ready-to-eat foods in restaurants with bare hands**
- **Food service industry can help foster an environment that promotes food safety and ensures that food service workers adhere to recommended practices**
- **Continued need for capacity of state and local health departments to investigate and report outbreaks**

# CDC Guidelines for Prevention and Control

[www.cdc.gov/mmwr/pdf/rr/rr6003.pdf](http://www.cdc.gov/mmwr/pdf/rr/rr6003.pdf)

- **Rapid reporting, response, and investigation**
  - Identify source and transmission mode
  - Collect appropriate specimens
- **Promote appropriate hand hygiene**
  - Wash with soap and water  $\geq 20$  seconds
  - Alcohol-based hand sanitizers?
- **Prompt and thorough disinfection**
  - Bleach solution for contaminated surfaces
  - Other EPA-approved disinfectants?
- **Manage and exclude ill persons**
  - $\geq 24$ -72 hrs after symptom resolution
  - Accommodating sick pay/leave policies



Hall 2011 MMWR

# Key Recommendations for the Food Service Industry

- **Underscore provisions in the FDA model Food Code and CDC guidelines**
  - **Practicing proper hand washing and using utensils and single-use disposable gloves to avoid touching ready-to-eat foods with bare hands**
  - **Certifying kitchen managers and training food service workers in food safety practices**
  - **Establishing policies that require food service workers to stay home when sick with vomiting and diarrhea and for at least 48 hours after symptoms stop**





# Norovirus Vaccine Development

- **Two randomized double blind placebo-controlled multicenter trials with healthy adults 18-50 years old:**
  1. **Intranasally delivered Norwalk virus (genotype GI.1) VLP vaccine followed by homologous challenge**
    - Vaccine protected against illness (~50%) and decreased infection frequency (~25%)
    - First demonstration that a norovirus vaccine can prevent disease
  2. **Intramuscular bivalent (GI.1 and consensus GII.4) VLP vaccine followed by GII.4 challenge**
    - Did not significantly reduce illness or infection, but did reduce disease severity and decreased viral shedding
    - Hampered by low disease rate from challenge and high baseline infection rate in control group
- **Key questions remaining: duration of immunity, cross-protection, other formulations, target populations**

**Atmar 2011 NEJM  
Bernstein 2014 JID  
Aliabadi 2015 ERV**

# Norovirus Vital Signs Report

## [www.cdc.gov/vitalsigns/norovirus/](http://www.cdc.gov/vitalsigns/norovirus/)

Centers for Disease Control and Prevention

# MMWR

Morbidity and Mortality Weekly Report

Early Release / Vol. 63

June 3, 2014

## Vital Signs: Foodborne Norovirus Outbreaks — United States, 2009–2012

Aron J. Hall, DVM<sup>1</sup>, Mary E. Wikswo, MPH<sup>1</sup>, Kimberly Pringle, MD<sup>2</sup>, L. Hannah Gould, PhD<sup>3</sup>, Umesh D. Parashar, MBBS<sup>4</sup>  
(Author affiliations at end of text)

### Abstract

**Introduction:** Norovirus is the leading cause of acute gastroenteritis and foodborne disease in the United States, causing an estimated one in 15 U.S. residents to become ill each year as well as 56,000–71,000 hospitalizations and 570–800 deaths, predominantly among young children and the elderly. Whereas noroviruses often spread through person-to-person contact, foodborne transmission can cause widespread exposures and presents important prevention opportunities.

**Methods:** CDC analyzed 2009–2012 data on suspected and confirmed norovirus outbreaks reported by state, local, and territorial health departments through the National Outbreak Reporting System (NORS) to characterize the epidemiology of foodborne norovirus outbreaks.

**Results:** During 2009–2012, a total of 1,008 foodborne norovirus outbreaks were reported to NORS, constituting 48% of all foodborne outbreaks with a single known cause. Outbreaks were reported by 43 states and occurred year round. Restaurants were the most common setting (64%) of food preparation reported in outbreaks. Of 520 outbreaks with factors contributing to contamination reported, food workers were implicated as the source in 70%. Of 324 outbreaks with an implicated food, most resulted from food contaminated during preparation (92%) and food consumed raw (75%). Specific food categories were implicated in only 67 outbreaks; the most frequently named were vegetable raw crops (e.g., leafy vegetables) (30%), fruits (21%), and mollusks (19%).

**Conclusions:** Noroviruses are the leading cause of reported foodborne disease outbreaks and most often associated with contamination of food in restaurants during preparation by infected food workers.

**Implications for Public Health Practice:** Improved adherence to appropriate hand hygiene, excluding ill staff members from working until ≥48 hours after symptom resolution, and supervision by certified kitchen managers are all recommended to reduce the incidence of foodborne norovirus disease.

### Introduction

Noroviruses are the leading cause of both sporadic cases and reported outbreaks of acute gastroenteritis (diarrhea or vomiting) in the United States (1,2). Each year, there are an estimated 19–21 million cases of norovirus disease, including 1.7–1.9 million outpatient visits, 400,000 emergency department visits, 56,000–71,000 hospitalizations, and 570–800 deaths, which result in approximately \$777 million in health-care costs (2). Rates of severe outcomes, such as hospitalization and death, are greatest in children aged <5 years

and older adults aged ≥65 years (2). Symptoms include vomiting, diarrhea, and sometimes fever, although norovirus infections also can be asymptomatic (3). This genetically diverse group of viruses comprises six genogroups (GI–GVI), three of which (GI, GII, and GIV) cause human disease (4). Genogroups are further subdivided into at least 38 known norovirus genotypes; GII.4 strains cause most outbreaks worldwide (5).

Transmission of norovirus occurs primarily via the fecal-oral route, including direct person-to-person contact, consumption



U.S. Department of Health and Human Services  
Centers for Disease Control and Prevention

 **20M**

About 20 million people get sick from norovirus each year, most from close contact with infected people or by eating contaminated food.

**#1**

Norovirus is the leading cause of disease outbreaks from contaminated food in the US.

 **70%**

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

**Vital** CDC **signs**<sup>TM</sup>

June 2014

## Preventing Norovirus Outbreaks

Food service has a key role

Norovirus often gets attention for outbreaks on cruise ships, but those account for only about 1% of all reported norovirus outbreaks. Norovirus is very contagious, and outbreaks can occur anywhere people gather or food is served. People with norovirus usually vomit and have diarrhea. Some may need to be hospitalized and can even die. Infected people can spread norovirus to others through close contact or by contaminating food and surfaces. Food service workers who have norovirus can contaminate food and make many people sick. In norovirus outbreaks for which investigators reported the source of contamination, 70% are caused by infected food workers.

The food service industry can help prevent norovirus outbreaks by:

- Making sure that food service workers practice proper hand washing and avoid touching ready-to-eat foods, such as raw fruits and vegetables, with their bare hands before serving them.
- Certifying kitchen managers and training food service workers in food safety practices.
- Requiring sick food workers to stay home, and considering use of paid sick leave and on-call staffing, to support compliance.

→ See page 4

Want to learn more? Visit

<http://www.cdc.gov/vitalsigns>

National Center for Immunization and Respiratory Diseases  
Division of Viral Diseases



# www.cdc.gov/norovirus

## Norovirus



Language: English ▾

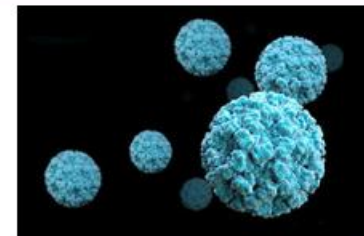
Español: [Norovirus](#)



Norovirus is a very contagious virus that can infect anyone. You can get it from an infected person, contaminated food or water, or by touching contaminated surfaces. The virus causes your stomach or intestines or both to get inflamed. This leads you to have stomach pain, nausea, and diarrhea and to throw up. These symptoms can be serious for some people, especially young children and older adults...

[More >](#)

## Norovirus Collection



[The Global Burden of Norovirus & Prospects for Vaccine Development](#) 

This PLOS norovirus collection fills critical knowledge gaps and provides key information for the development of a much-needed vaccine. This is a "living collection" and more articles will be added over time.

Have You Ever Heard of Norovirus?



**Protect Yourself  
from Norovirus!**



Wash your  
hands often

# Thank You... Questions?

- Collaborating CDC Programs
- State, Local, and Regulatory Partners
- USDA-NIFA Food Virology Collaborative (NoroCORE)



For more information please contact Centers for Disease Control and Prevention

1600 Clifton Road NE, Atlanta, GA 30333

Telephone, 1-800-CDC-INFO (232-4636)/TTY: 1-888-232-6348

E-mail: [cdcinfo@cdc.gov](mailto:cdcinfo@cdc.gov) Web: [www.cdc.gov](http://www.cdc.gov)

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.



**HAVE YOU  
EVER  
HEARD OF NOROVIRUS?**

