NOROVIRUS 101

VIRUS BACKGROUND AND OVERVIEW

National Environmental Health Association – Food Safety Webinar Series

Clyde “Chip” Manuel, PhD - GOJO Industries

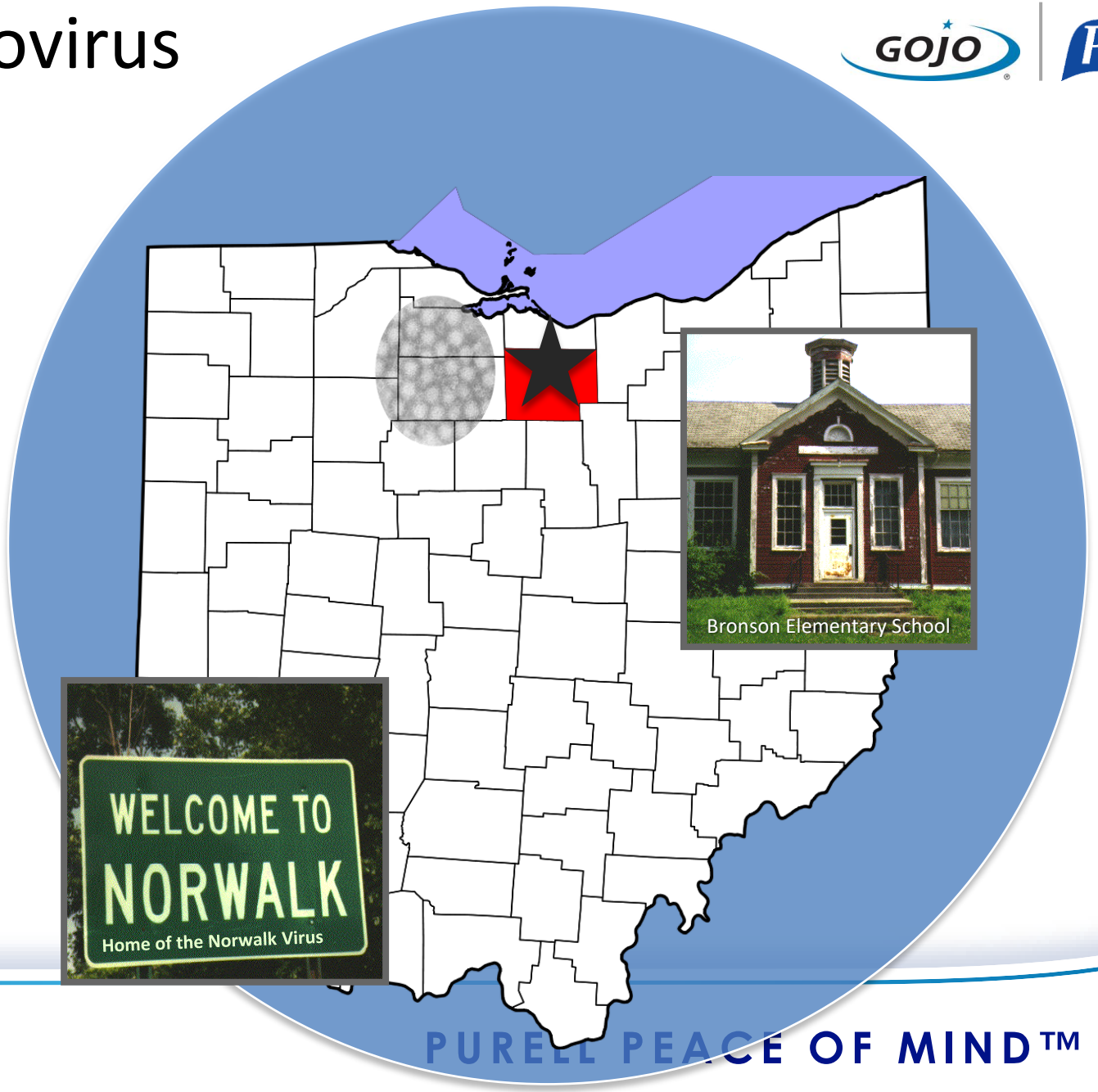
AGENDA

- Norovirus Overview
  - History and Discovery
  - Structure and Basic Virology Considerations
  - Characteristics of “A Perfect Pathogen”
- Considerations for Controlling Norovirus in Food Handling Settings
- Key Takeaways

Ohio: Home of the Norovirus

“Norwalk virus” (NoV)

The first Norovirus identified as a cause of gastroenteritis following an outbreak of “winter vomiting disease” at an elementary school in Norwalk, Ohio in 1968.



Nor-OH-Virus

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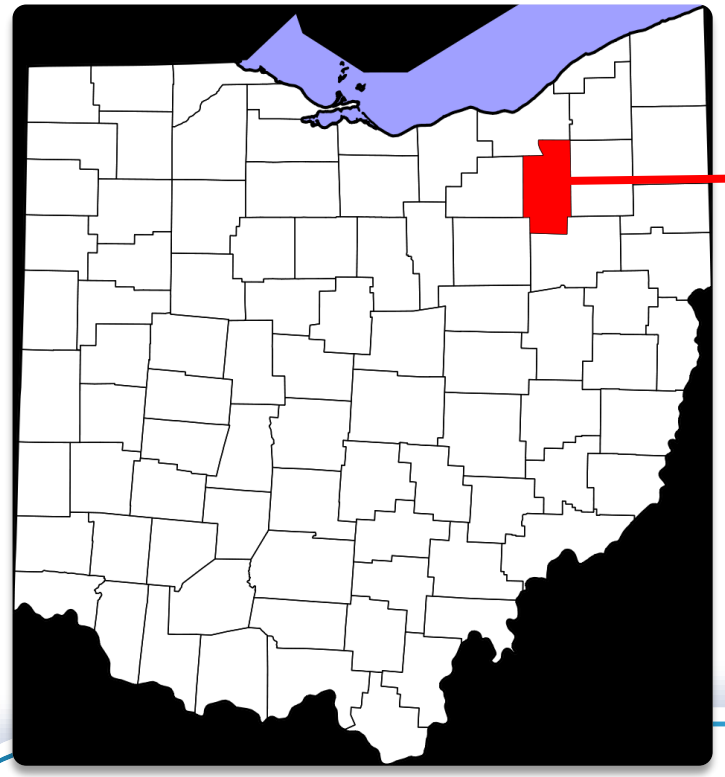
OHIO IS ALSO HOME OF GOJO, A GLOBAL LEADER IN HYGIENE SOLUTIONS SINCE 1946



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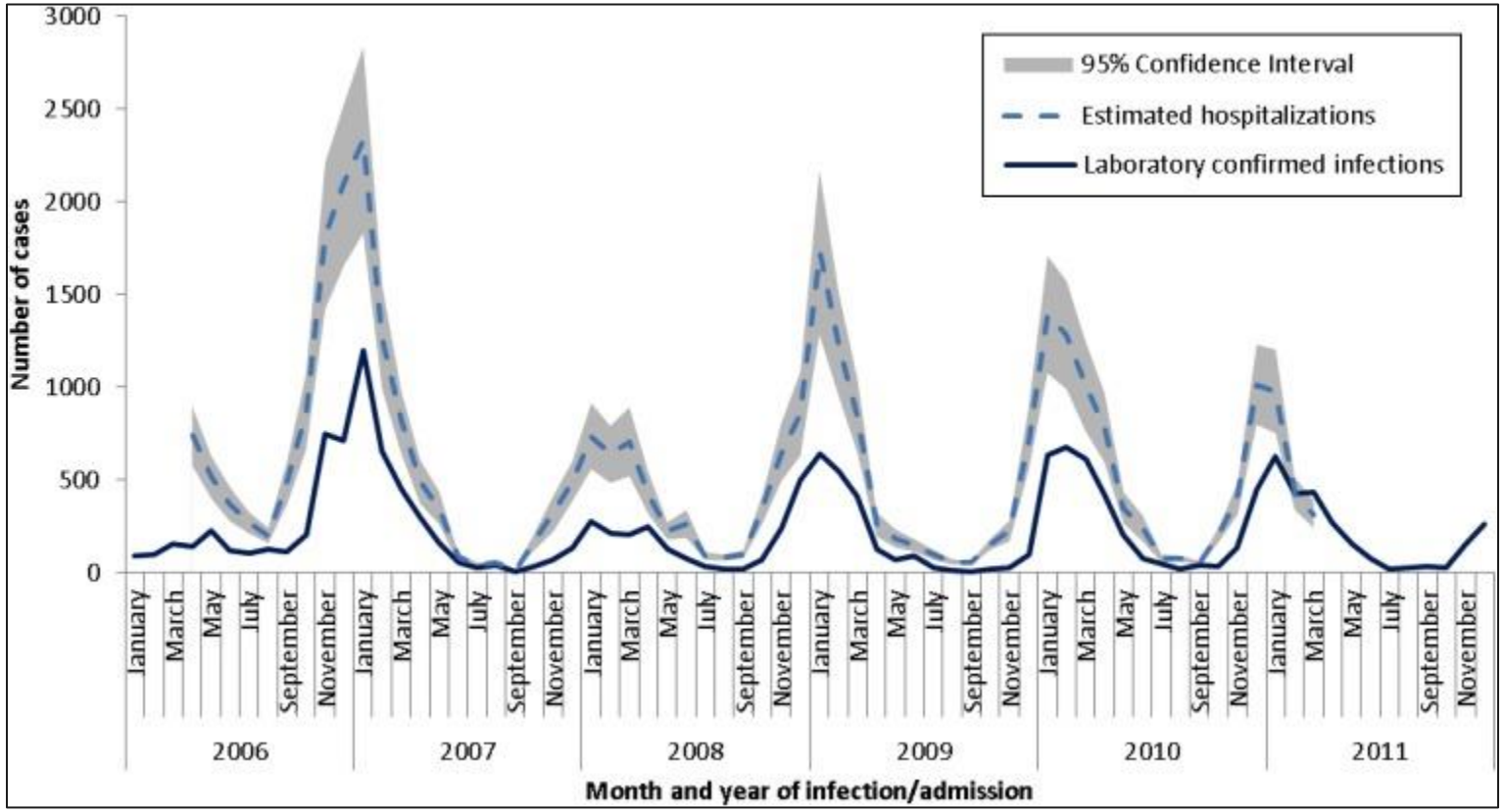
NOROVIRUS OVERVIEW

HISTORY OF NOROVIRUS

- Before discovery, often called “winter vomiting disease” (coined in late 1920s)



Epidemiol Infect. 2015 Dec; 143(16): 3528–3537.

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HISTORY OF NOROVIRUS

- Key outbreak – 1968 in Norwalk, OH
  - Halloween outbreak – 116 of 232 students ill
  - 32% of students spread the infection to family members at home
  - Rectal swabs were taken from patients and saved for research purposes

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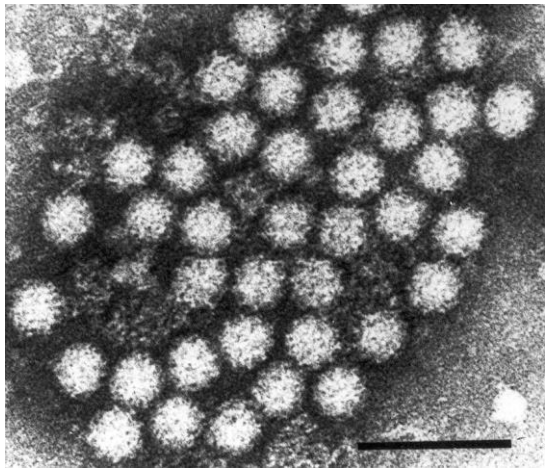
FIRST VISUALIZATION OF THE VIRUS

- In 1972, researchers fed stool filtrate from the 1968 outbreak to inmate volunteers from Maryland State Correctional Facility
  - Volunteers became ill, and researchers examined stool by Immune Electron Microscopy
  - Discovery of the “Norwalk Agent”

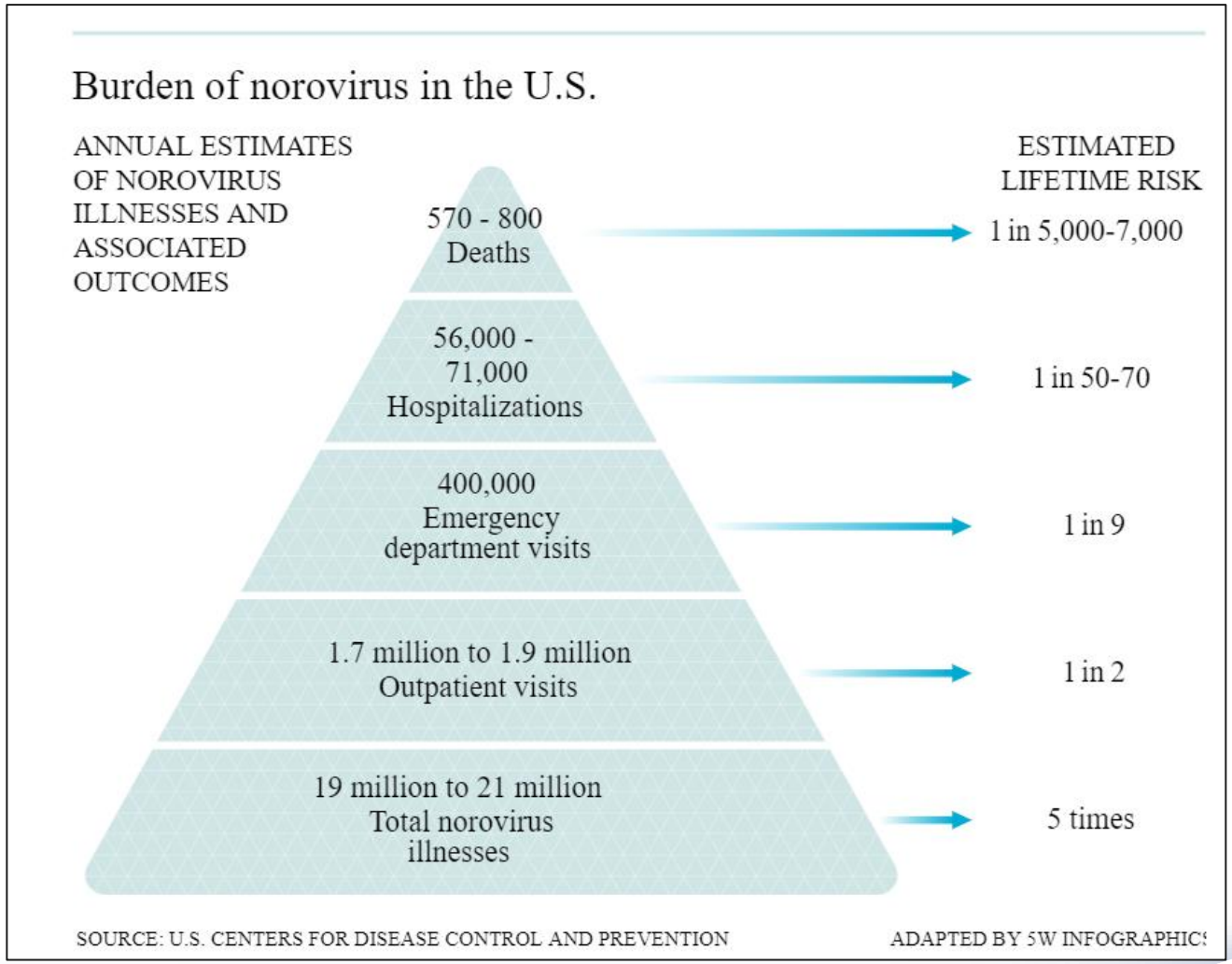
Dr. Albert Kapikian
(1930-2014)



J Virol. 1972 Nov; 10(5): 1075–1081.

SYMPTOMS AND ILLNESS BURDEN

- Disease Characteristics
  - Causes vomiting (hallmark symptom), diarrhea, abdominal cramping, and nausea
  - Onset is 12-48h, duration 12-60h
  - Asymptomatic viral shedding is common
- Disease Burden
- Transmission Routes
  - Person to Person, fomites, contaminated food/water



1 Emerg Infect Dis. 2013 Aug; 19(8): 1198–1205.

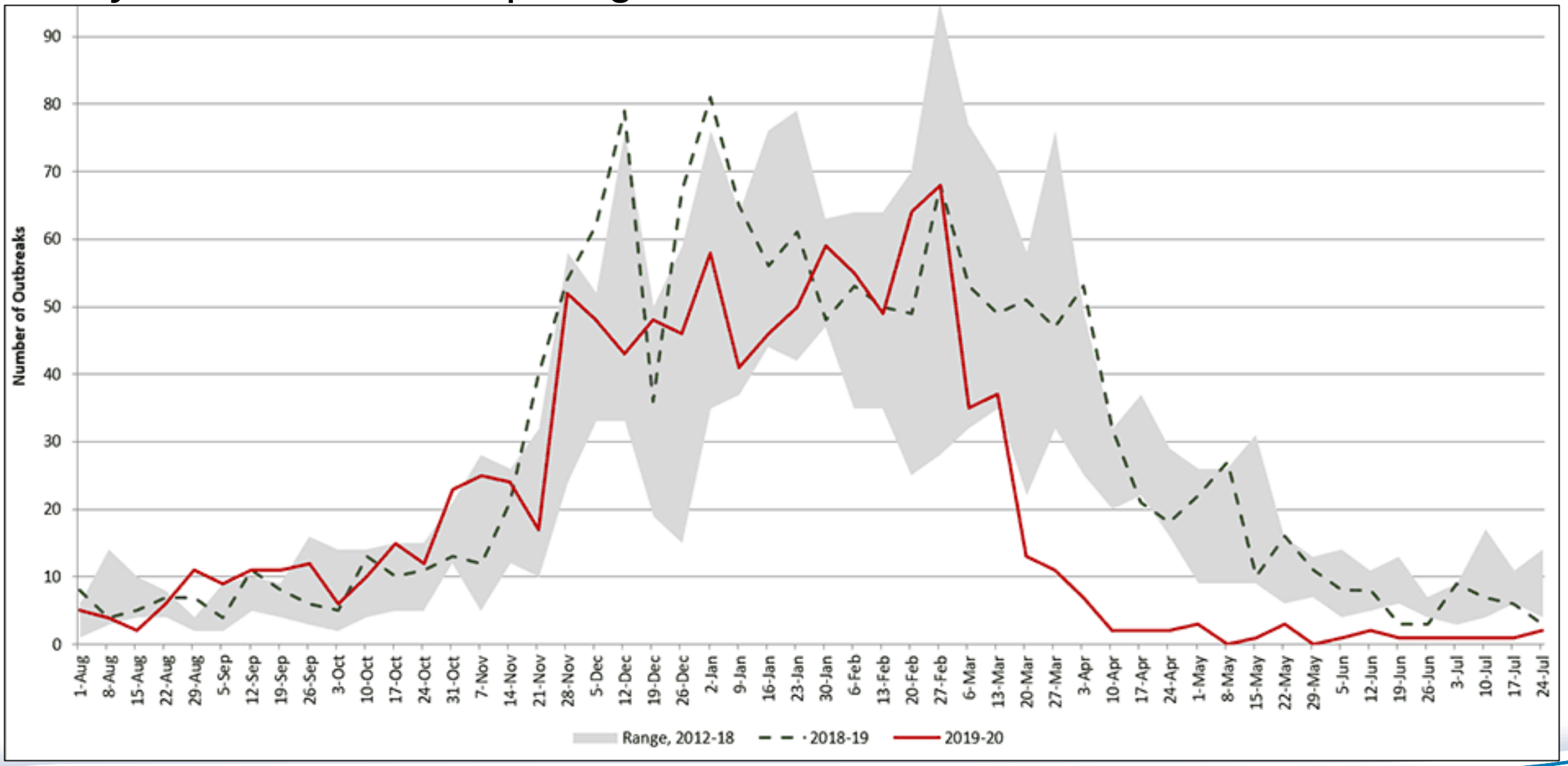
BURDEN OF FOODBORNE NOROVIRUS IN THE UNITED STATES

	Illnesses	Hospitalization	Death
1st	**Norovirus (58%)**	Nontyphoidal Salmonella spp. (35%)	Nontyphoidal Salmonella spp. (28%)
2nd	Nontyphoidal Salmonella spp. (11%)	**Norovirus (26%)**	Toxoplasma gondii (24%)
3rd	Clostridium perfringens (10%)	Campylobacter spp. (15%)	Listeria monocytogenes (19%)
4th	Campylobacter spp. (9%)	Toxoplasma gondii (8%)	**Norovirus (11%)**

Costs $2 billion per year in medical care services and lost productivity

Scallan 2011 EID Hoffmann 2012 slide courtesy Dr. Wang –OSU-OARDC

Number of Suspected or Confirmed Norovirus Outbreaks Reported by NoroSTAT-Participating States Per Week, 2012-2020



Source: CDC, https://www.cdc.gov/norovirus/reporting/norostat/data.html

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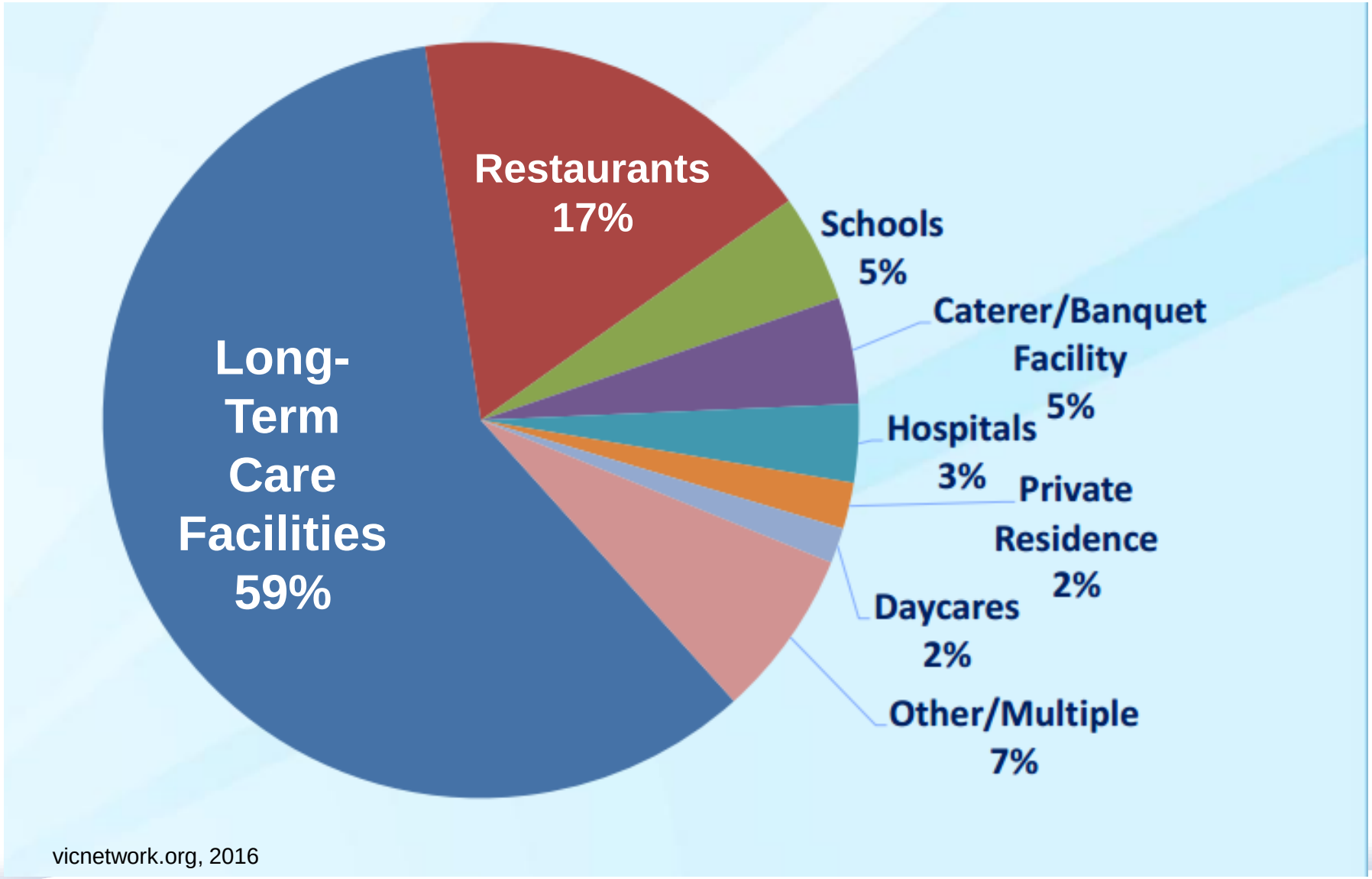
MAIN SETTINGS FOR NOROVIRUS OUTBREAKS



vicnetwork.org, 2016

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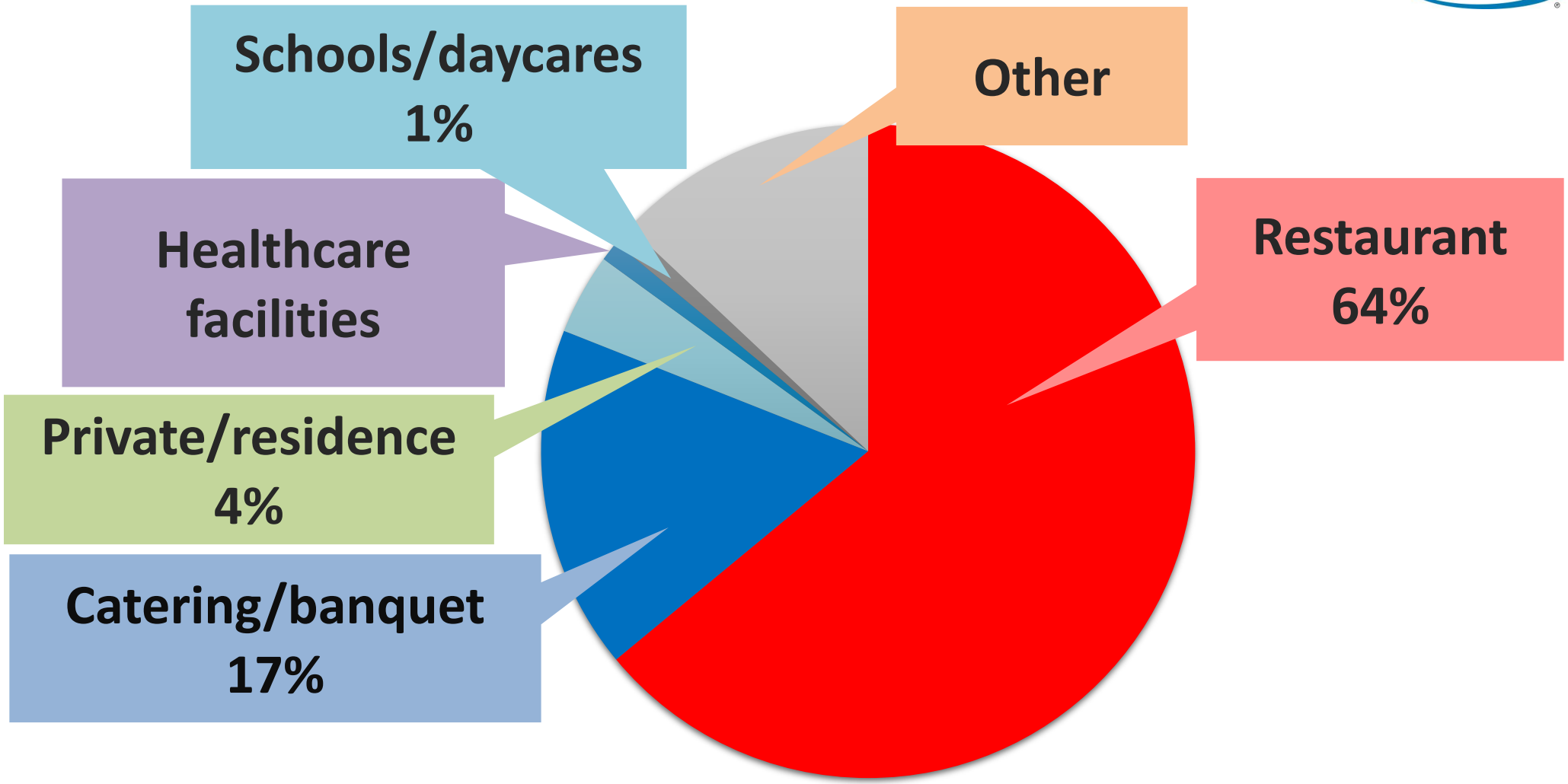
WHERE DO NOROVIRUS OUTBREAKS FROM FOOD CONTAMINATION HAPPEN?

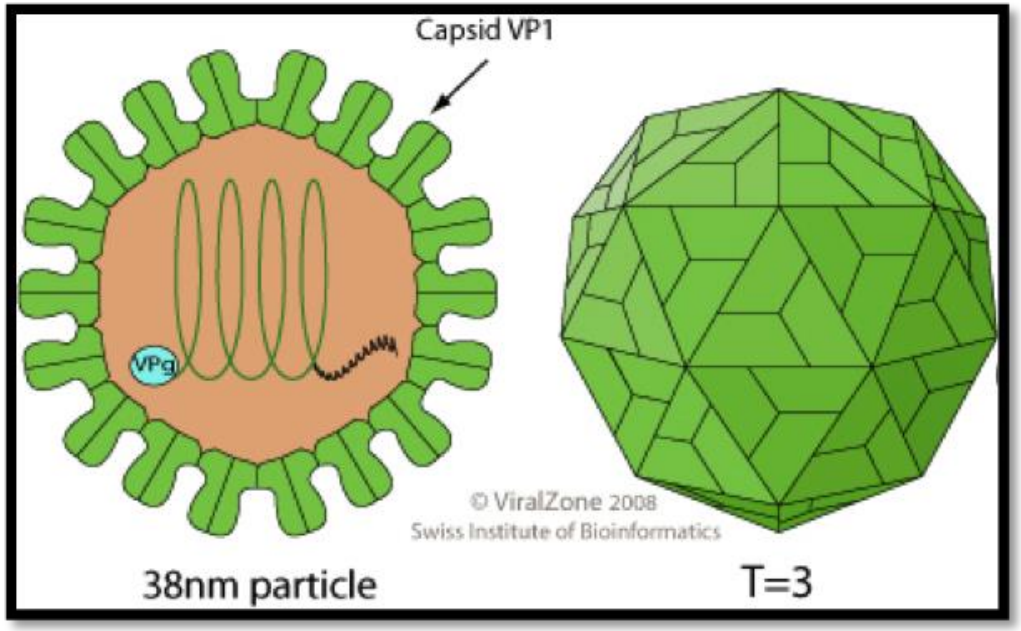


SOURCE: CDC National Outbreak Reporting System, 2009-2012

NOROVIRUS STRUCTURE

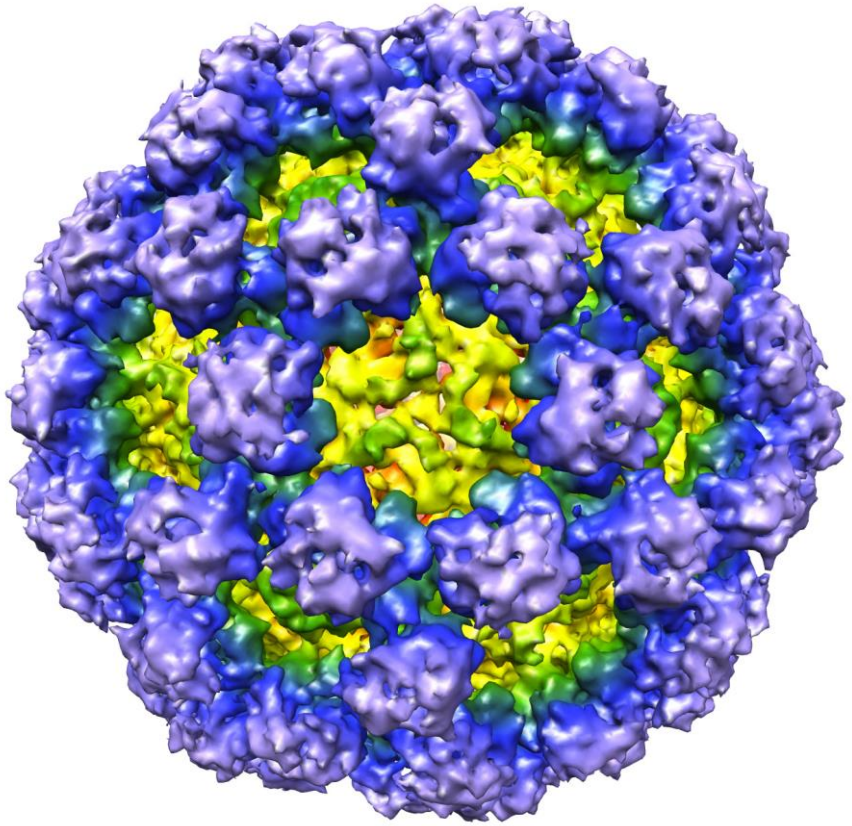
- Noroviruses are very simple
- Two main components:
  - Capsid (protein shell – 23-40nm in diameter)
  - Genome (+ RNA; ~7.5kb in length)

- **This simplicity is part of the reason these viruses are difficult to inactivate**



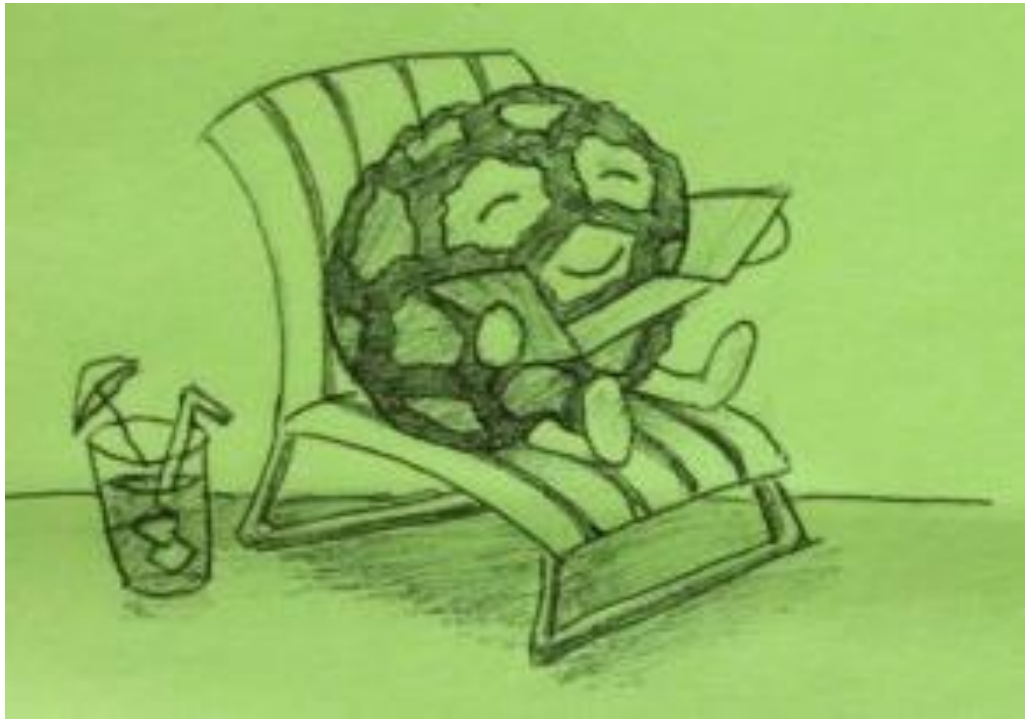
Structure = Function

- **Capsid –** Protein based shell
  - Function:
    - 1) facilitates entry into host cell
    - 2) protects genome (shield)
    - **Both are critical for viral survival**
- Simplicity of Norovirus capsid makes it hardy
  - Amino acids resistant to many forms of attack and degradation



Source: Dr. Grant Hansman (http://hansman-lab.com)

A Word on Non-Enveloped vs. Enveloped



Non-enveloped:

- More resistant to heat and chemicals
- Can persist on surfaces for long periods of time (weeks)

Enveloped:

- Lipid membrane sensitive to heat, UV, and many chemicals
- Generally does not persist for longer periods of time on surfaces

Courtesy of Liz Bradshaw, Ph.D

Noroviruses: The Perfect Human Pathogens?

Aron J. Hall Division of Viral Diseases, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia

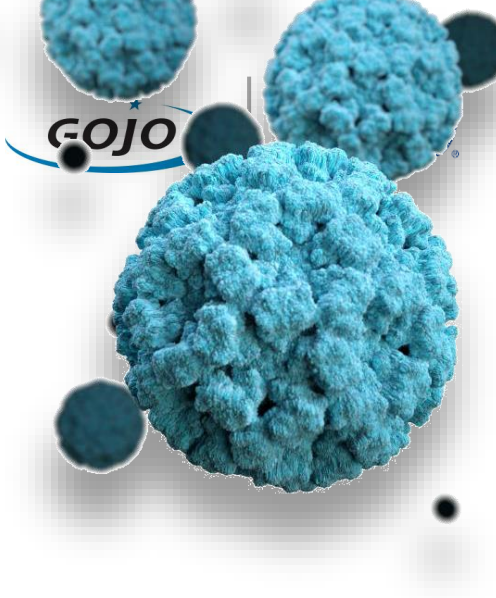
Aron J. Hall
J Infect Dis (2012) 205 (11): 1622-1624

WHAT MAKES NOROVIRUSES SO SUCCESSFUL AS A PATHOGEN?

Highly Contagious: extremely low infectious dose

- 18 –1,000 virus particles

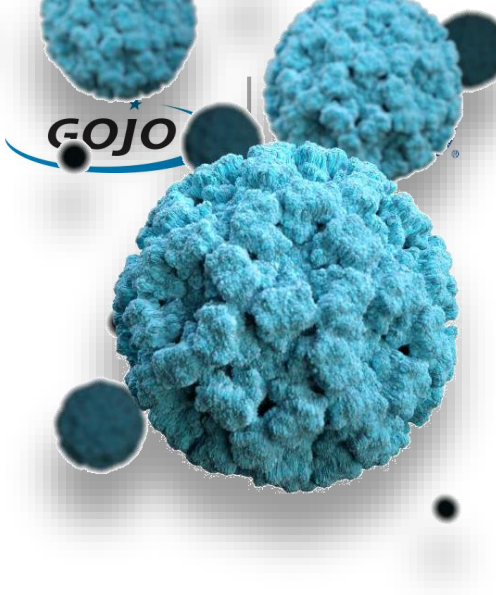
WHAT MAKES NOROVIRUSES SO SUCCESSFUL AS A PATHOGEN?



Multiple routes of transmission

- **Mainly Fecal-Oral: Person-to-person; contaminated foods or water**
- **Handling of contaminated fomites, followed by hand-to-mouth contact**
- **Via ingestion of aerosolized particles-vomitus / toilet flush (unique among enteric pathogens)**

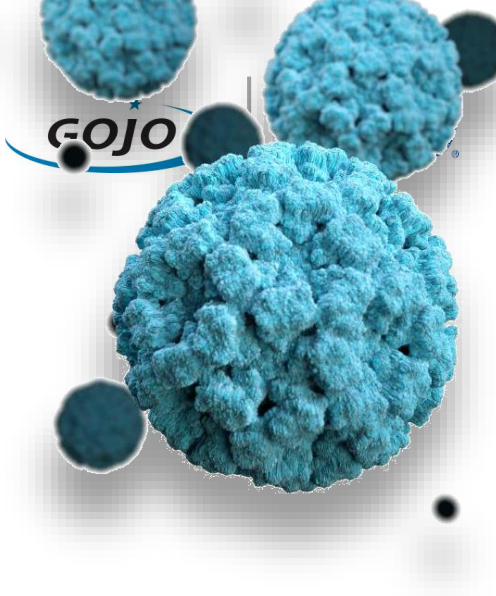
WHAT MAKES NOROVIRUSES SO SUCCESSFUL AS A PATHOGEN?



Rapidly and prolifically shed

- **Stool shedding =** 10^5–10^{11} **viral copies per gram of feces**
- **Vomitus = average** 1.7×10^8 **genomic equivalent copies per mL**

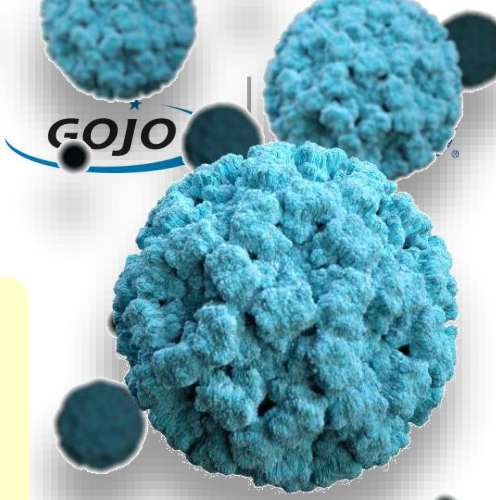
WHAT MAKES NOROVIRUSES SO SUCCESSFUL AS A PATHOGEN?



Prolonged virus shedding and infections without symptoms make it easier to transmit virus

- **Occurs for at least 2 to 3 weeks but can be much longer**
- **Peaks 4 days after exposure**

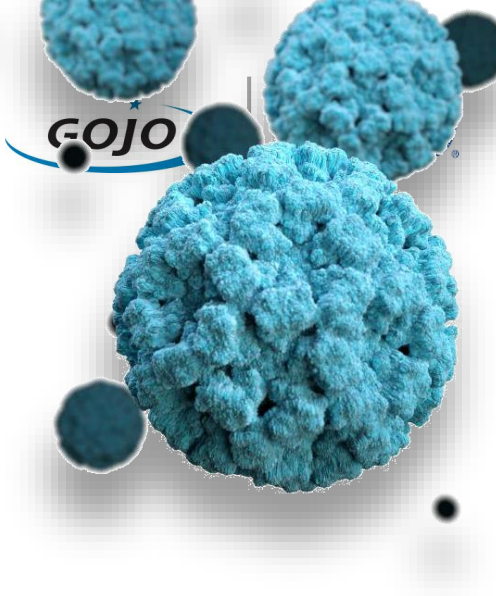
WHAT MAKES NOROVIRUSES SO SUCCESSFUL AS A PATHOGEN?



High environmental stability

- **Resists:** Gut environment – very low pH, freezing and heat temperatures up to 140° F, several disinfectants
- **Persists:** On human hands for at least two hours, on common surfaces for at least 3 to 6 weeks
- **Remains:** Infectious in water for at least 60 days, stable on foods for hours – weeks

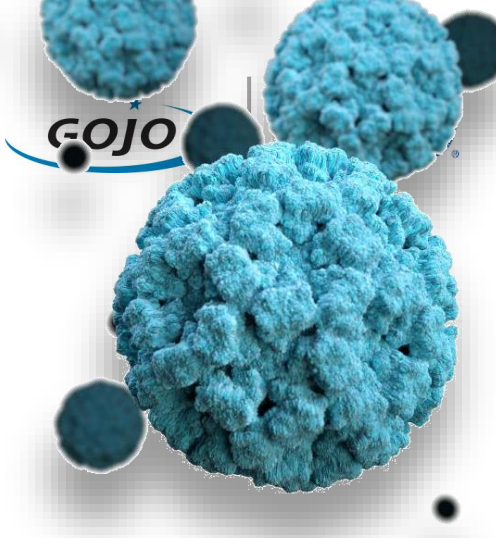
WHAT MAKES NOROVIRUSES SO SUCCESSFUL AS A PATHOGEN?



Genetically diverse group of viruses that rapidly evolve

- **Strain-specific immunity is short lived; weeks to months – 6 months up to 5 years**

WHAT MAKES NOROVIRUSES SO SUCCESSFUL AS A PATHOGEN?

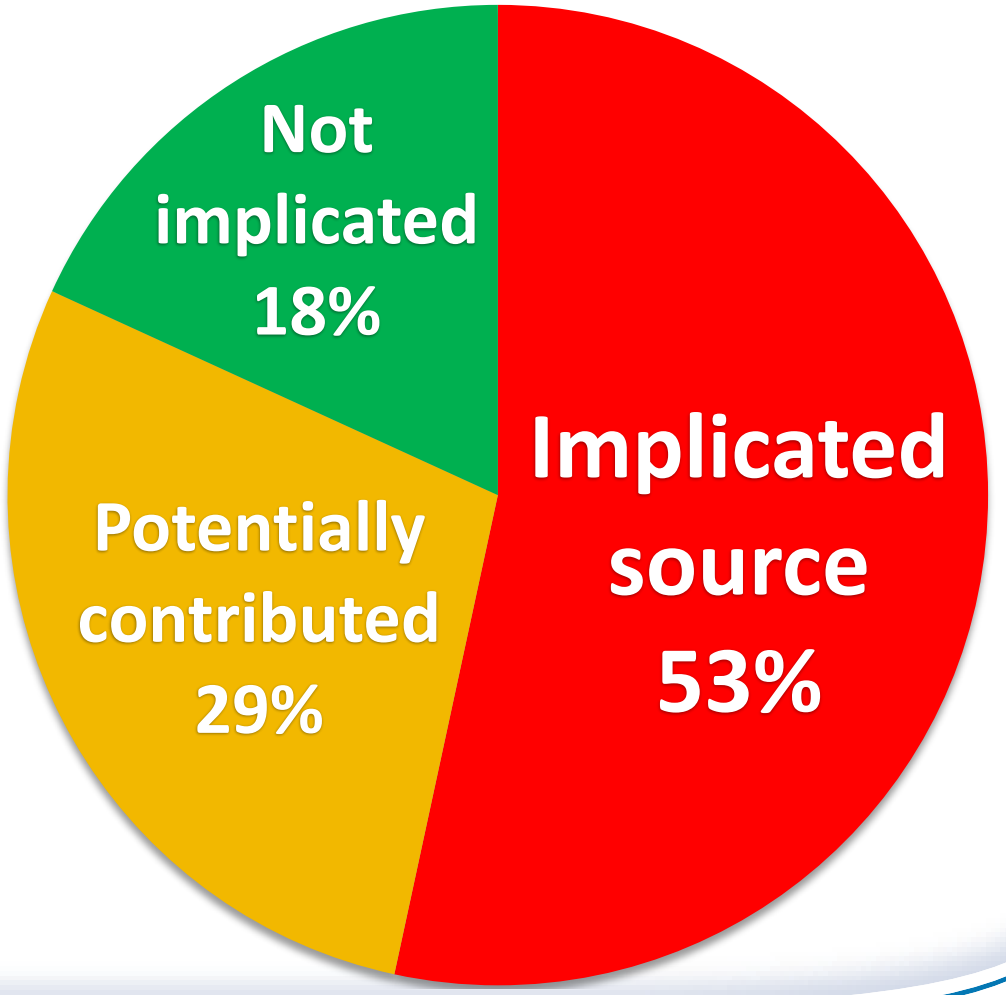


Widespread host susceptibility

- Only ~20% population is resistant

a large susceptible pool of hosts
(Except children and elderly)

THE ROLE OF FOOD WORKERS IN FOODBORNE NOROVIRUS OUTBREAKS = 80%!!



MMWR *website (http://www.cdc.gov/mmwr), Hall et al, 2012 .*

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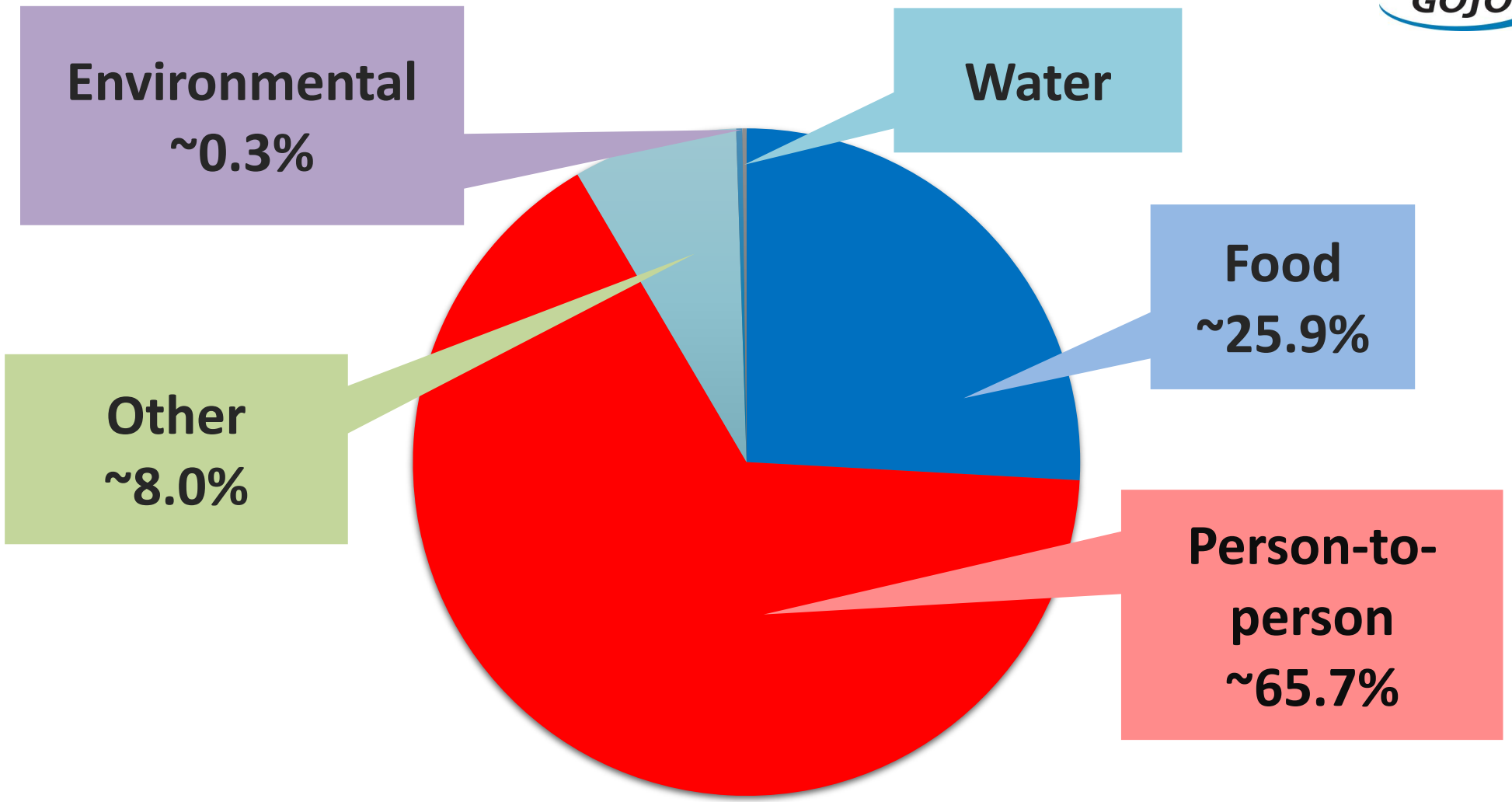
HOW NOROVIRUS IS TRANSMITTED



Wikswo et al. Surveillance Summaries, December 11, 2015 / 64(SS12);1-16

Risk Analysis DOI: 10.1111/risa.12758

Quantitative Risk Assessment of Norovirus Transmission in Food Establishments: Evaluating the Impact of Intervention Strategies and Food Employee Behavior on the Risk Associated with Norovirus in Foods

Steven Duret, Régis Pouillot, Wendy Fanaselle,* Efstathia Papafragkou, Girvin Liggans, Laurie Williams, and Jane M. Van Doren

1 MAR 2017 DOI: 10.1111/risa.12758 http://onlinelibrary.wiley.com/doi/10.1111/risa.12758/full#risa12758-fig-0001

NOROVIRUS RISK FACTORS & PREVENTION SCENARIOS IN RETAIL FOOD ESTABLISHMENTS

Approach:

Create a mathematical model to predict number of NoV illnesses on a daily basis from a typical retail food establishment

BASELINE

Using scientific evidence, determine impact of various factors (e.g., handwashing, touch points, disinfectants, etc.) on reduction of NoV as compared to baseline

SCENARIOS

Determine which factors have highest contribution to NoV illness. Make recommendations on best practices

OUTPUT

Risk Analysis. 2017 Nov;37(11):2080-2106

THE IMPACT OF DIFFERENT INTERVENTIONS ON THE REDUCTION OF NOROVIRUS OUTBREAKS

Exclusion from work of symptomatic food employee

Full Compliance: 75% reduction
No Exclusion: 226% increase

Efficient Hand Washing

58% reduction

Handwashing frequency associated with gloving compliance

62% reduction

Elimination of contact between hands, faucets, doors handles

75% reduction

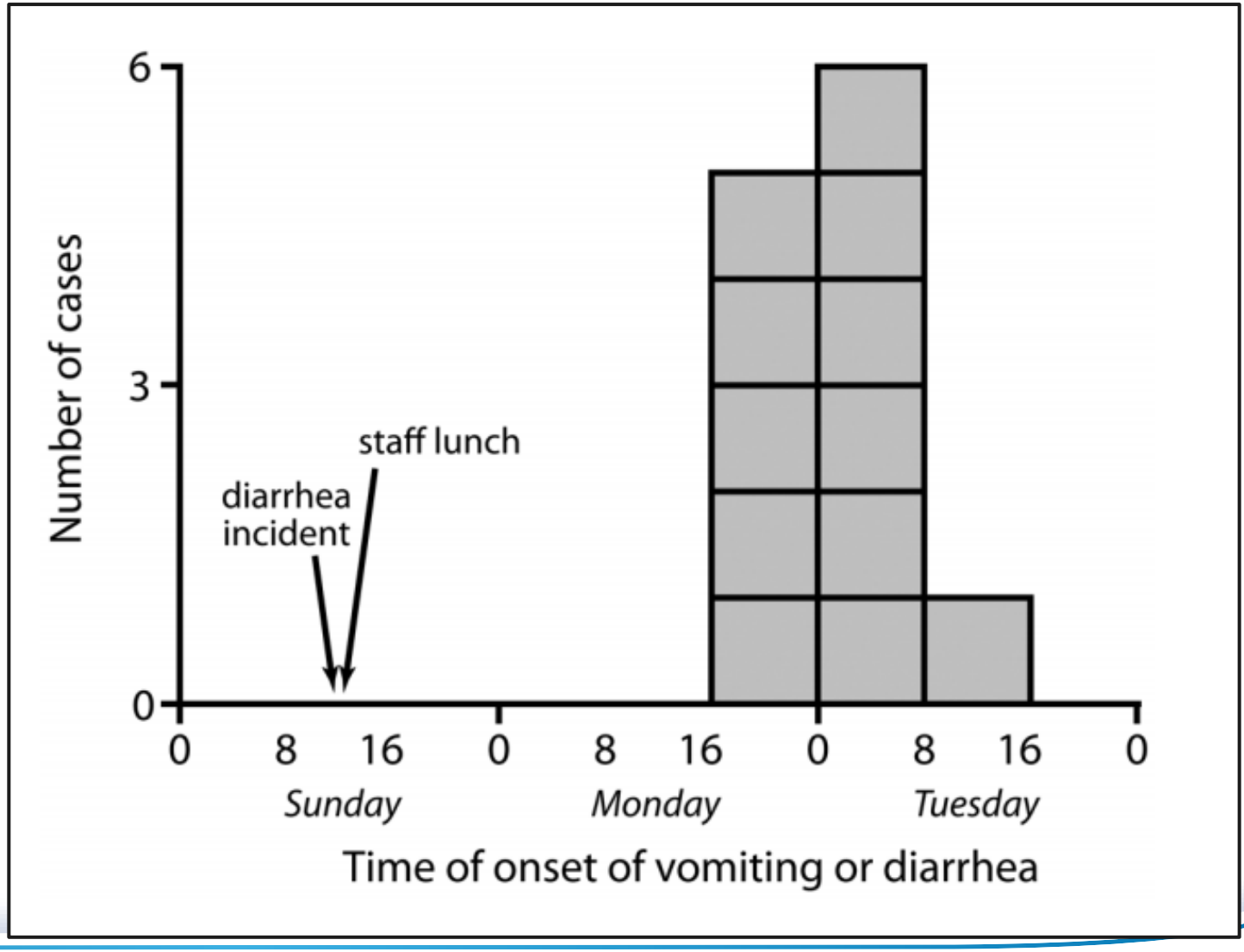
Risk Analysis. 2017 Nov;37(11):2080-2106

A Norovirus Outbreak Related to Contaminated Surfaces

Kimberly K. Repp,[1] Trevor P. Hostetler,[1] and William E. Keene[2]

[1]Washington County Department Health and Human Services, Hillsboro; and
[2]Oregon Public Health Division, Portland, Oregon

- 12 out of 16 employees infected during staff luncheon
- Sandwich shop originally thought to be culprit
- Outbreak investigation found diaper changing station to be culprit



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KEY TAKEAWAYS:

- Norovirus is highly persistent and infectious, and is the major cause of foodborne illness in the United States
- Best practices for management:
  - Keep sick employees OUT!
  - Emphasize proper and frequent hand hygiene
  - Emphasize proper and frequent disinfection, using EPA approved products with fast kill times on key touch surfaces and after a vomit or diarrhea incident. Always follow label instructions!
  - Have a Plan - Train staff on how to manage vomit and/or diarrheal incidents – they will happen, It's just a matter of time.

THANK YOU
QUESTIONS AND SUGGESTIONS

Contact Information:

- **ManuelC@GOJO.com**

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