

Running the Race... or...Racing the Runs? Controlling a Norovirus Outbreak

EOPIC February 12, 2008

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Acknowledgement to Dr. Robert Wheeler
and slides from Webber Training



Norovirus in the News 2008

Google News February 6, 2008



Bug forces hospital ward closure

- BBC News, UK - 19 hours ago
A hospital spokesman said those affected on ward 14 had suffered sickness and diarrhoea - symptoms consistent with the **norovirus**. ...

Bug hits wards at Ninewells Evening
Telegraph

Vomit Bug Hits Wards Glasgow Daily Record



Norovirus reaches epidemic levels

- Times Online, UK - 12 Jan 2008
The winter vomiting bug **norovirus** has struck **2.8million people**, with health professionals braced for another rise as people return to schools and offices. ...



Norovirus - a nauseating story

- Times Online, UK - 15 Jan 2008
It is caused by the **norovirus**, a bug that is easily spread. NHS wards are closed, factories stuttering, schools trembling to reopen after the Christmas ...



Norovirus outbreak at nursing home

- WSLs.com, VA - 4 Feb 2008
Norovirus starts as vomiting diarrhea, and stomach cramps but the symptoms usually last 1 or 2 days and usually there are no long term side effects.



'Norovirus' Outbreak In NJ Sends Hundreds To ER

- WCBS-TV New York, NY - 30 Jan 2008
The **norovirus**, commonly known as the "stomach flu", has taken a stronghold of a large portion of the Garden State. Hospital officials have reported the ...



Hotel responds to **norovirus** cases

- **San Mateo County Times, CA - 2 Feb 2008**
... say an upscale Redwood City hotel has cleaned up its act after 62 people came down with **norovirus stomach flu** following an event there last week. ...

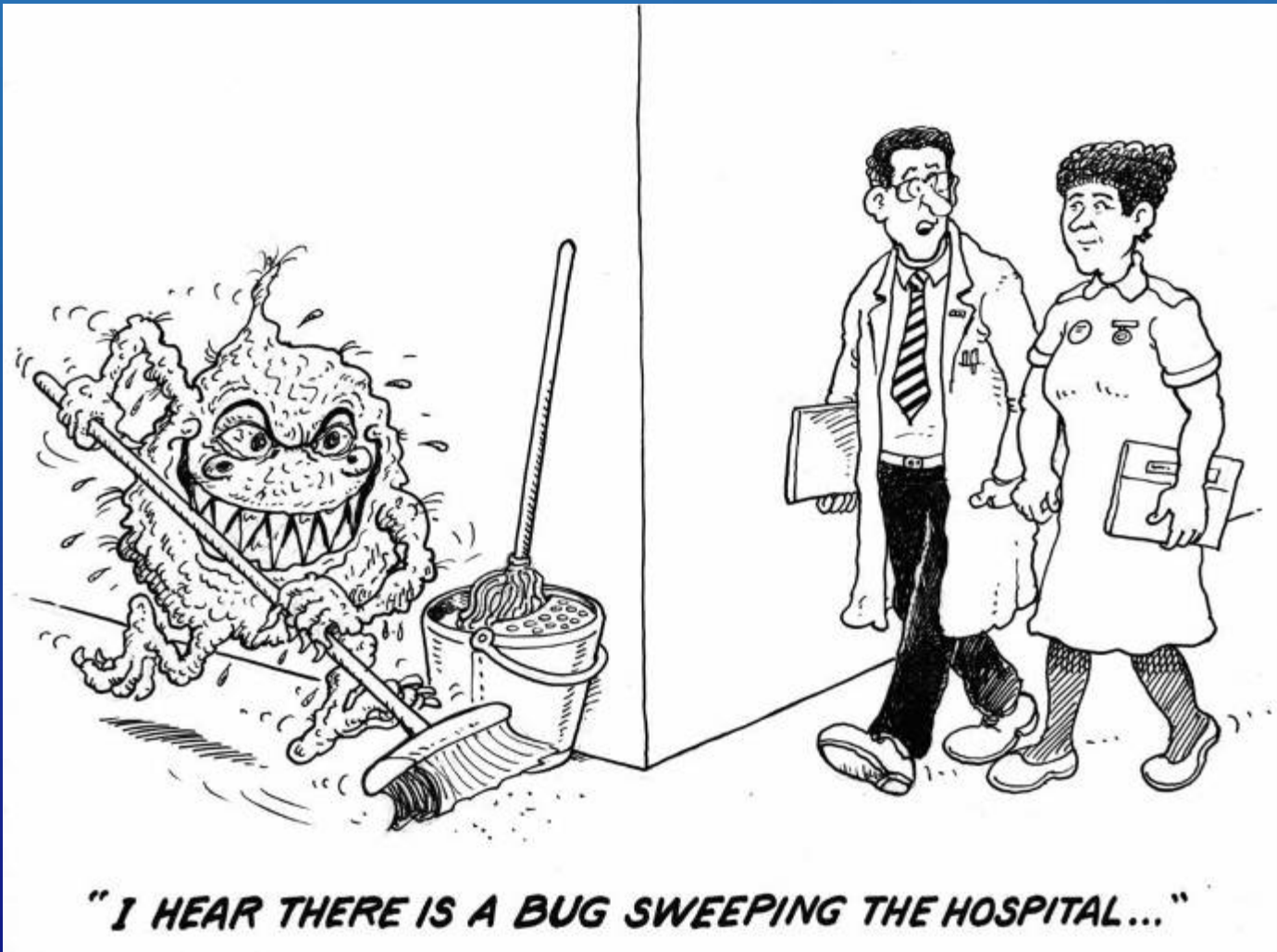


Norovirus sweeps 2 Boston hospitals

➤ Boston Globe, United States - 7 Jan 2008

The outbreaks of **norovirus** spawned several days of gastrointestinal misery at Brigham and Women's and Massachusetts General hospitals and at a day-care ...





North York General dealing with **norovirus**

➤ insideTORONTO.com, Canada - 29 Jan 2008

Dr. Kevin Katz, medical director of infection prevention and control, said **norovirus** was discovered at the Leslie Street and Hwy. 401 hospital Monday, Jan. ...



Is Norovirus an Emerging Disease?

- 1972: first virus definitively associated with acute gastroenteritis (AGE)
 - Not easily identified
 - 93-97: >2500 foodborne outbreaks reported to CDC, <1% attributed to norovirus; 68% “unknown”
- With RT-PCR most common cause of infectious AGE
 - Responsible for $\leq 50\%$ of foodborne outbreaks
 - 35% of sporadic AGE
 - 14% of all children hospitalized for AGE



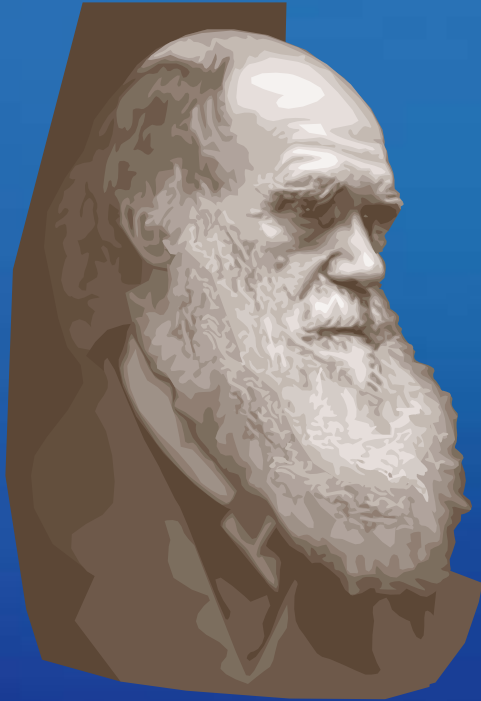
Beyond Improved Diagnostics

- Strains can periodically emerge, displace other strains and increase disease incidence
 - Winter 2002, virus variant
- Relative contribution of Norovirus to foodborne disease likely increasing
- Modern lifestyles and longevity increase vulnerability
 - ↑ nursing home beds
 - ↑ \$\$ eating out
 - ↑ fruits and vegetables from foreign countries
 - ↑ travel and crowding in hotels, airplanes, cruise ships

Objectives

- To review modes of transmission for Norovirus
- To discuss the role of environmental contamination with Norovirus
- To examine methods on interrupting Norovirus transmission
- To understand characteristics that facilitate Norovirus outbreaks





Norovirus

Survival of the Fittest....?



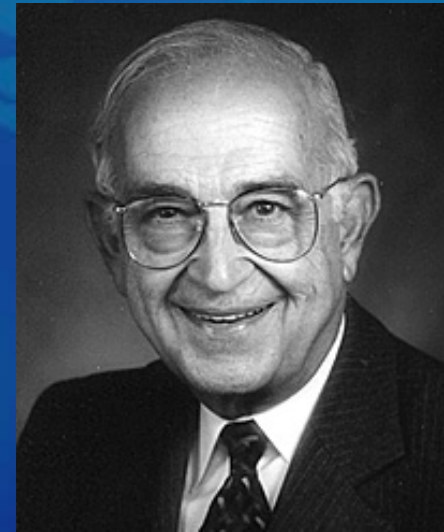
Norwalk – the history

- In 1968, >50% of students and teachers at an elementary school in Norwalk, Ohio, developed a stomach illness that involved nausea and vomiting.
- When they went home, 32% of household contacts also became ill.



Identification of the virus

- Dr. Albert Kapikian
- 1972, electron microscopy
- **S**mall **R**ound-**S**tructured **V**irus (SRSV)
- 27 nm



J Infect Dis. 2000
May; 181 Suppl 2:
S295-302.

The early years

- 1970s-1980s: No simple method available to detect Norwalk virus
- 1993-1997: >2,500 outbreaks reported to CDC
 - <1% attributed to Norwalk
 - 68% “unknown etiology”

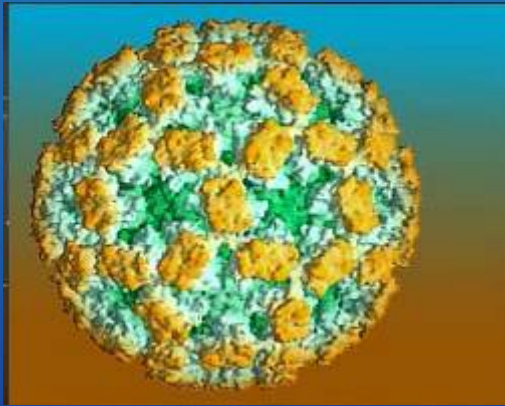


Reverse Transcription-PCR

- Early 1990s
- Today, Noroviruses recognized as the most common cause of infectious acute gastroenteritis (AGE)
- Responsible for ~50% of all foodborne AGE in the US



Norwalk-like virus

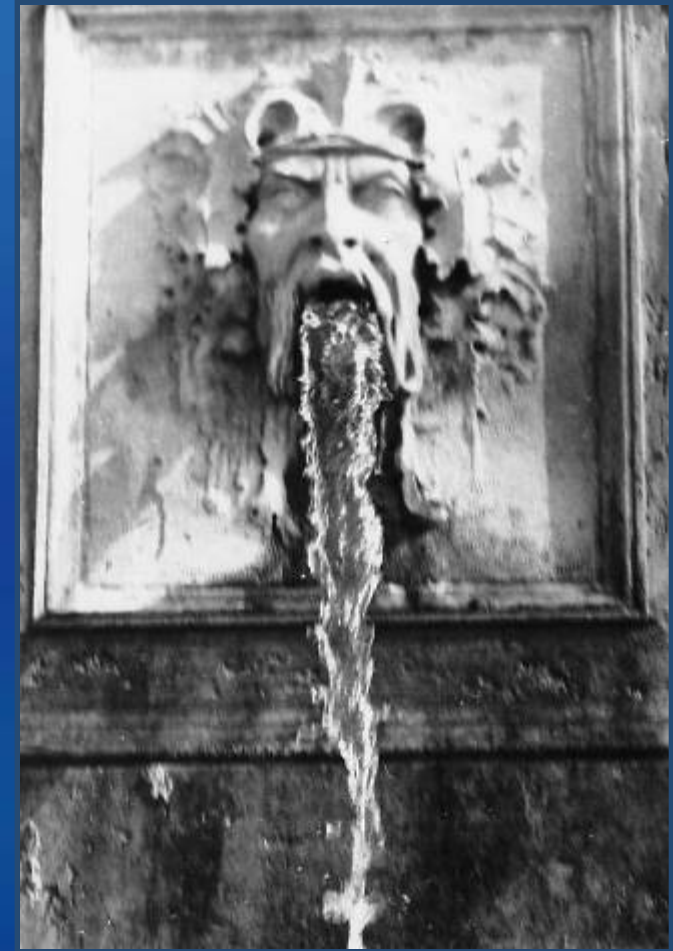


- 2002
 - Family – Caliciviridae
 - Genus – Norovirus
 - Genogroups – I - 5
 - Multiple clusters/strains
- Coat is made of a single protein, surrounds a single strand of RNA
- **Non-enveloped**
- Very stable and fairly resistant to chlorine
- Cannot be grown in cell culture



Signs and Symptoms

- Vomiting (>50% of patients), diarrhea, nausea, and abdominal pain
- Fever occurs in no more than 1/2 of cases and is low grade and transient
- Less frequently, myalgia, malaise and headache
- Dehydration in young and elderly victims
- Up to 30% may be asymptomatic

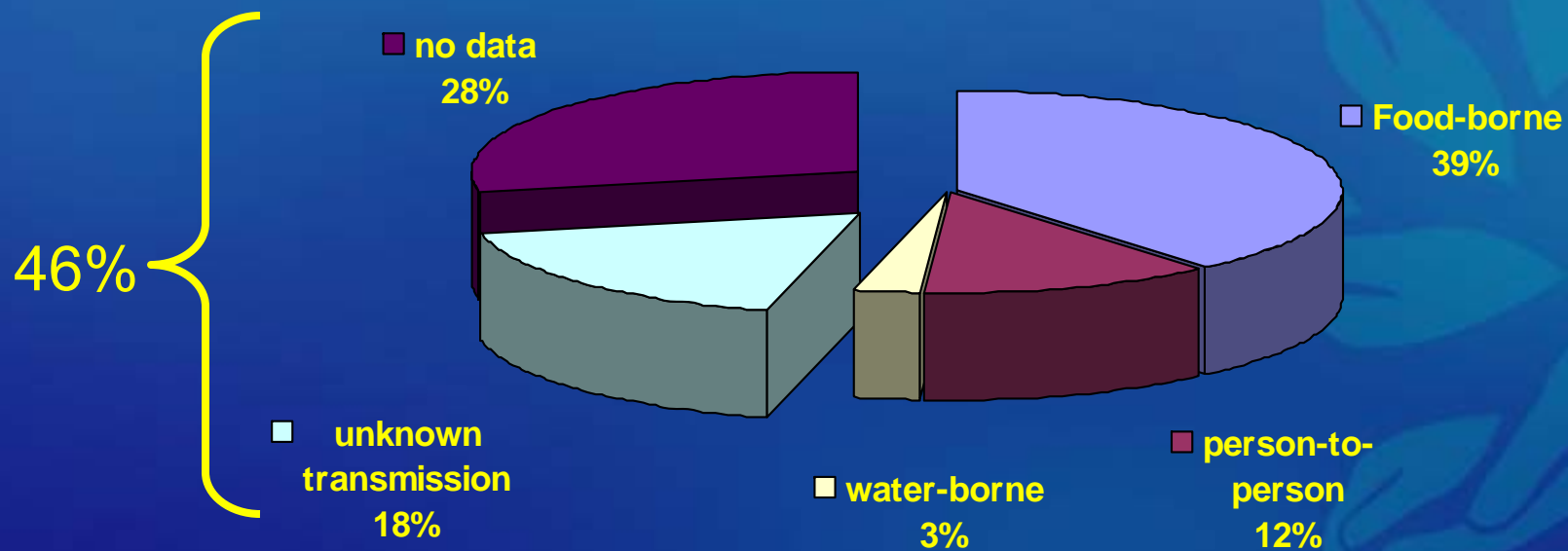


Infectious Disease Alert
22:11 Mar 1, 2003

Picture taken from slides
by Dr. Robert Wheeler

Mode of Transmission

348 Norovirus outbreaks reported to CDC January 1996 to November 2000



MMWR June 01, 2001 /
50(RR09);1-18

Norovirus

Water Contamination

- Typically via improper sewerage treatment or overflow
- Surface water
 - Ponds, lakes, streams, rivers, reservoirs
- Well water
- Swimming pool water
- Ice



Waterborne Transmission

- Outbreaks have been associated with sources of contaminated water, including municipal water, well water, stream water, commercial ice, lake water, and swimming pool water.
- Outbreak example: January-February 2002, Andorra.
 - Irish holiday-makers visiting Andorra.
 - Retrospective-cohort study conducted.
 - Risk exposure higher for tourists who stayed in Soldeu and consumed ice cubes in their drinks (OR 2.5) after logistic regression.



Foodborne Transmission

- Food contamination by infectious food handlers.
- Oysters and clams tend to concentrate in their tissues NLVs that contaminate the waters from which they are harvested.
- Steaming does not inactivate NLVs.
- Note: Norovirus does not multiply in foods.
- Outbreak example: Louisiana 1993-1996.
 - 3 outbreaks investigated.
 - Overboard disposal of sewage by oyster harvesters into oyster-bed waters was the most likely source of contamination.



Foods Most at Risk

- Shellfish (oysters, clams, mussels)
- Ready to eat foods that require handling but no subsequent cooking
 - Salads
 - Peeled fruits
 - Deli-sandwiches
 - Finger foods
 - Hors d'oeuvres
 - Dips
 - Communal foods



Slide adapted from
Dr. Robert Wheeler



How long does Norovirus last in Food?

- Study using Feline Calicivirus (FCV) as a surrogate
- Artificially contaminated lettuce, strawberries ham and stainless steel
- Virus survival greater at 4°C than at Room Temperature



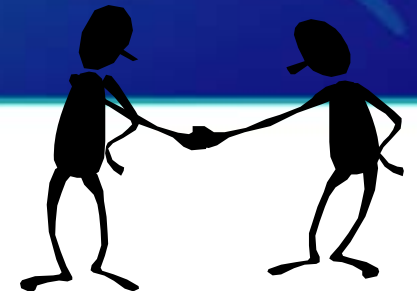
Recovery of FCV

	Strawberries	Lettuce	Ham	Stainless Steel
Room Temp	2 days	3 days	7 days	7 days
4°C	5 days	7 days	7 days	7 days

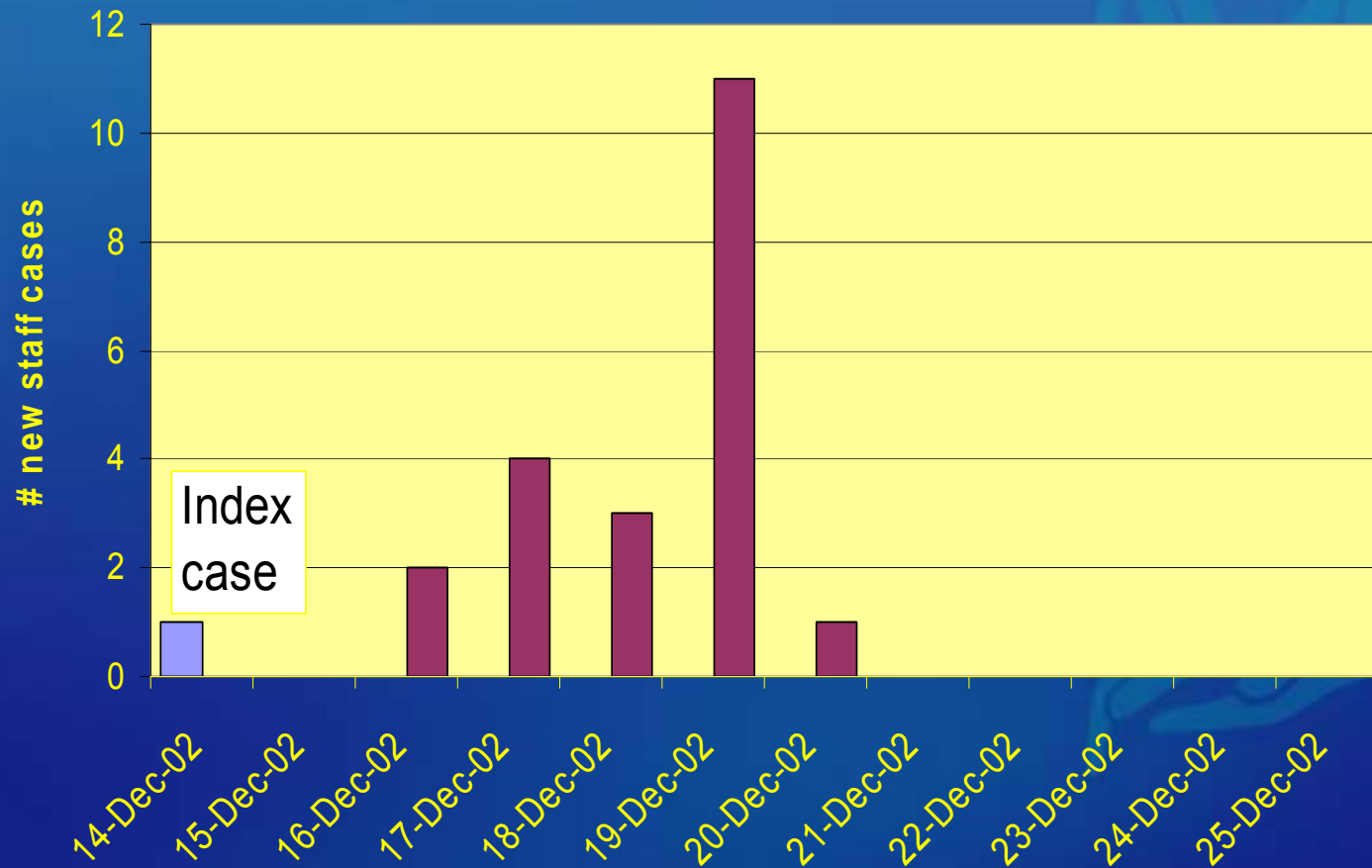


Person-to-Person Transmission

- Direct fecal-oral and “aerosol” transmission (during projectile vomiting and explosive diarrhea) and indirect fomite transmission
- Outbreak example: January 1999 (UK)
 - Concert attendee vomited in the auditorium and the adjacent male toilet.
 - The following day, 15 school parties attended the auditorium; AGE occurred in members of 8 of these schools.
 - In total, more than 300 people affected who attended the hall over a 5 day period.



Norovirus in the OR: An outbreak caused by all the right intentions.....



The Environment and Norovirus

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The 2004 Houseboat Vacation

- 3 x 5-night educational boating trips
- 54 participants (avg age 68.2)
- Likely index case on first excursion
- 20/27 interviewed fit case definition
- Overall attack rate 47%
- After 3rd trip, before cleaning, boats sampled



Norovirus RT-PCR samples

Boat	Bathroom	Kitchen	Door handles
1	1 (50%)	1 (100%)	1 (100%)
2	N/S	N/S	1 (100%)
3	4 (100%)	0 of 2	1 (100%)
4	N/S	1 (50%)	N/S
Total % positive	83%	40%	100%



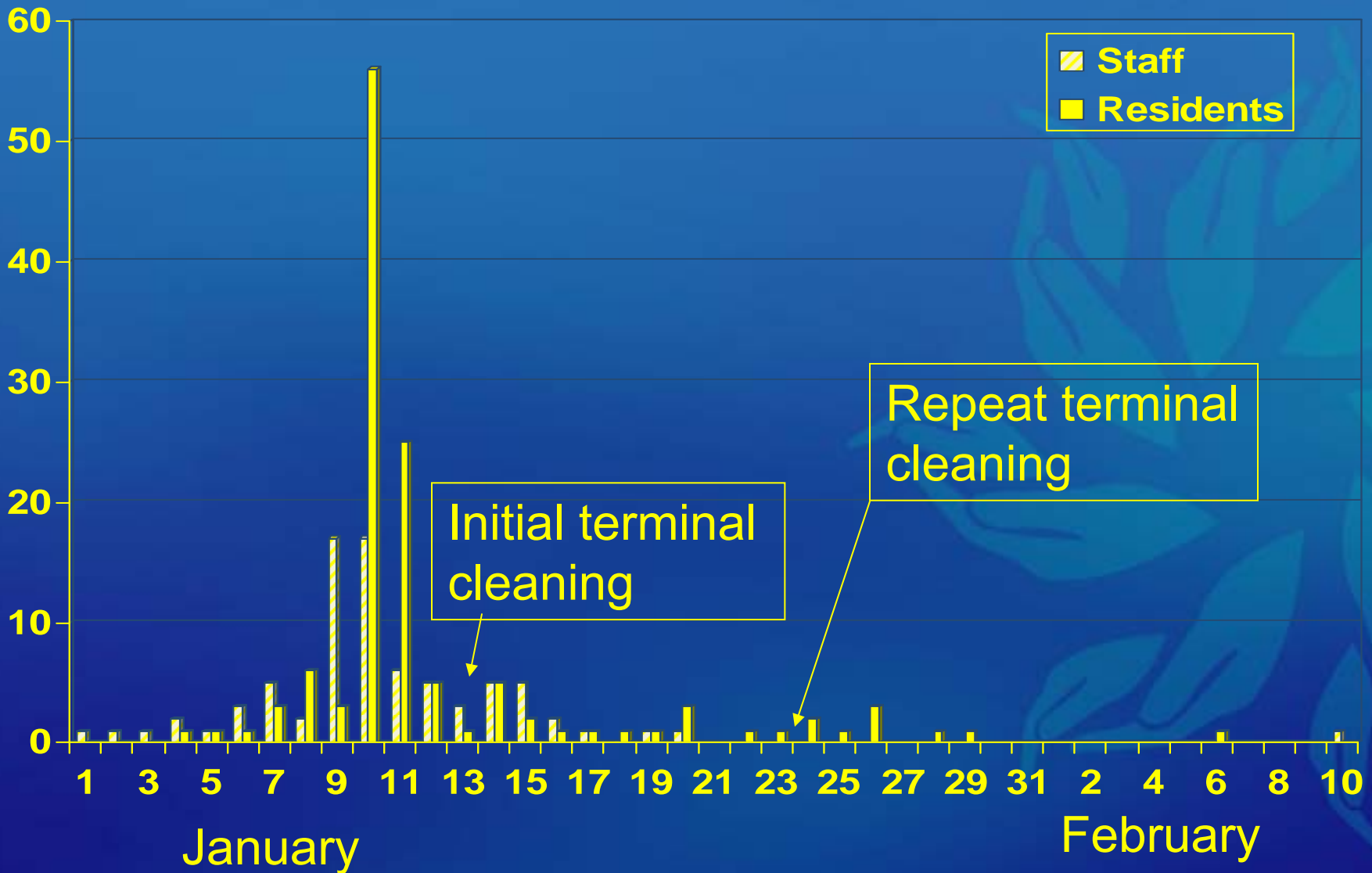
Widespread environmental contamination with NLV detected in a prolonged **hotel** outbreak of gastroenteritis

- RT-PCR environmental surface testing +
 - Carpets (known vomiting) 5/8 (62%)
 - Carpets (no vomiting) 9/12 (75%)
 - Toilet rims/seats 8/11 (73%)
 - Toilet handles/sinks/basins 13/39 (39%)
 - Horizontal surfaces below 1.5 m 11/29 (37%)
 - Horizontal surfaces above 1.5 m 6/12 (50%)
 - Phones, door handles, etc. 7/29 (24%)
 - Soft furnishings 2/10 (20%)
 - Total 61/144 (42%)

It's Everywhere!

Prolonged Outbreak at a LTCHF

- Jan-Feb 2002
- 240 veterans LTCHF in Philadelphia
- 127 (52%) residents and 84/181 (46%) staff
- Positive environmental cultures:
 - Toilet seat (2 days after onset)
 - Common Dining Table
 - Bedrail (2 days after onset)
 - Toilet seat and handle (same day as onset)
 - Elevator button (used only by staff)



Wu, HM, ICHE 2005;
26(10): 802-810

Environmental Survival

- Norovirus cannot be propagated in vitro
- Therefore, cannot measure survivability directly
- Feline Calicivirus (FCV) is used as a surrogate

FCV

Donor Card



Name: **DIVA**

Age: **4 years**

Breed: **Persian**

Attitude: **BAD**



Uncommon fomites

- Computer mouse and keyboard keys
- Brass discs (representing water faucets or door knobs)
- Telephone wire, receiver and buttons
- Artificially contaminated
- Organism sampled at 0, 4, 8, 12, 24, 48, 72, 96, 120 and 144 hours

Fomite	Time to 90% reduction in virus titre (hr)	Time to undetectable virus (hr)
Keyboard keys	0-4	8-12
Computer mouse	0-4	24-48
Brass	0-4	8-12
Telephone buttons	12-24	48-72
Telephone receiver	4-8	48-72
Telephone wire	0-4	24-48

Clay et al. AJIC 2006;
34(1): 41-44

Transfer from the Environment to Food (part 1)

- Samples of Formica, Stainless Steel and ceramic artificially inoculated with NoV and FCV
- Virus eluted at 0.5 hrs, 1, 2, 4, 8, 24, 48 and 168 hrs
- Infectious FCV detected by plaque assay on all 3 surfaces after 7 days (although there was a 6-7 \log_{10} drop in titre



Transfer from the Environment to Food (part 2)

- Wet and Dry lettuce samples applied to artificially contaminated stainless steel
- Pressures equated with weight of a head of lettuce

	10 min	30 min	60 min
Wet Lettuce	+ve	+ve	+ve
Dry Lettuce	+ve	-ve	-ve



The baker who should have known better...

- 16 Jan 2001 – 800-900 staff members attend a luncheon at a restaurant
- 18 Jan – 80 staff members report in sick (V&D); by end of day, 200 sick
- Food histories taken by email contact
- Case control of 20 ill and 20 well people submitted stool samples
- Also all persons at the restaurant who handled food submitted stool samples (5 of 8 ill)



Investigation

- Stools tested for bacterial and viral pathogens, with early testing for Norovirus
- Environmental, food and water samples taken (all negative)
- Multivariate analysis of questionnaires implicated the rolls as a possible source (showed doubling of OR of becoming sick with each additional roll eaten)
- Further investigation revealed rolls made by outside bakery



At the bakery

- Baker had become ill during the night 2 days before reception
- In the morning, vomited in the sink
- Cleaned the sink with chlorine and washed hands
- During preparation, rolls had contact with hands, the counter and other staff hands
- 3 of the bakers staff subsequently became ill
- 15 days later, NoV found in stool

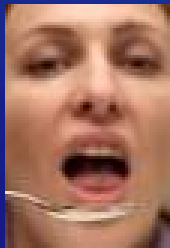


Amount of NoV excreted in the vomitus and feces of infected individuals: 10^4 to 10^6 virus particles (vp) per gram (10,000 – 1,000,000)



Small amount of fecal or vomitus contamination on a surface (e.g. 20 mg) – 10^2 to 10^4 vp (100-10,000)

Assume a 5% transfer rate from the surface to food (5-500 vp)



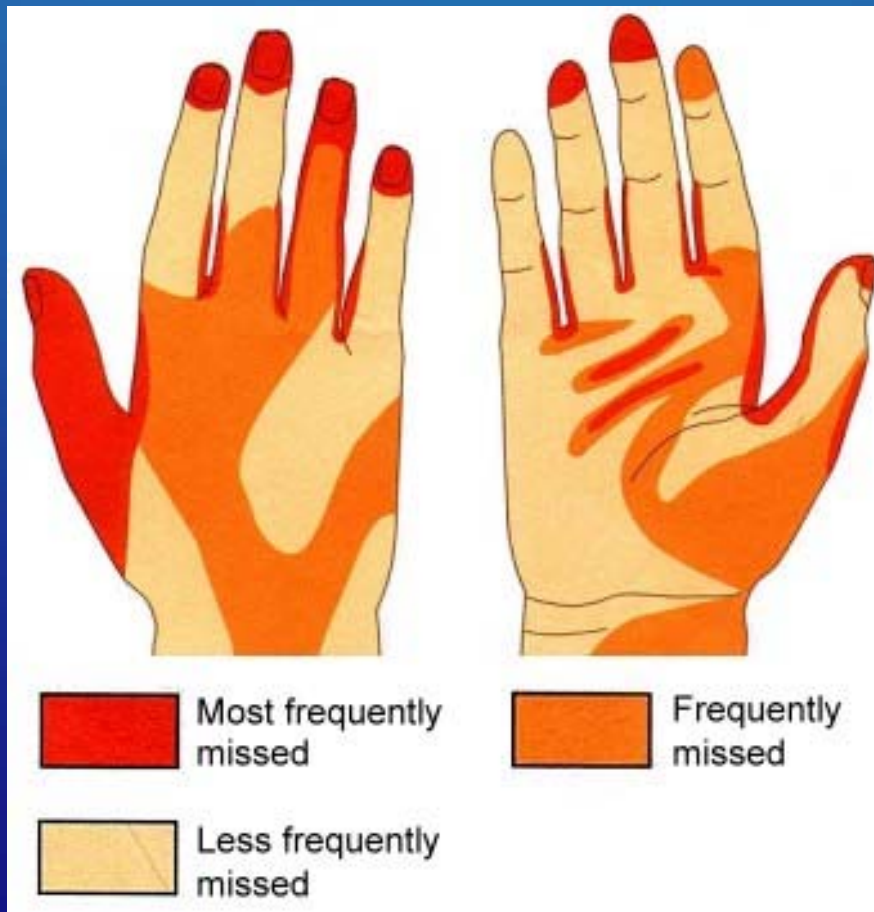
Infectious dose of Norovirus: 10- 10^2 viral particles (10-100)



So what can we do?



Hand Hygiene



- Contaminated hands are probably the single most common vector for the spread of Norovirus

The Importance of Hand Hygiene

- Fingers can transfer NoV to melamine surfaces, and from there to other typical hand contact surfaces
- Taps, door handles, telephone receivers
- Contaminated fingers can sequentially transfer the virus to seven clean surfaces



Hand Hygiene

- It's all good
- Alcohol-based hand sanitizers (ABHS) contain ethanol; 1-propanol or 2-propanol or a combination
- Antimicrobial activity results from their ability to de-nature proteins
- Products with 60-90% concentrations most effective



ABHS and viruses

- Generally, activity against viruses is less than against bacteria
- However, Boyce and Pittet have shown that 60-80% ethanol provides a 0.8 to >3 log reduction depending on
 - Viral strain
 - Nature of alcohol
 - Concentration of alcohol

Log Reduction Factor of Alcohols with 30 second contact time

	95% ethanol	70% ethanol	70% 1-propanol	70% 2-propanol	other
Gerhke 2004	(90%) 2.84	3.78	3.58	2.15	
Kampf 2005	2.66	1.53	1.09	N/A	
Lages 2008	(99.5%) 1.0	(62%) 0.5	0.67	N/A	10% PI 2.67

** A log reduction of 2-3 is necessary for considering a product as an effective hand sanitizer

Gehrke, C, J Hosp Inf 2004;56:49-55 // Kampf, G, J Hosp Inf 2005;6:144-49 // Lages SLS, J Hosp Inf 2008: 1-6



New combination ABHS Formula

- Newer product with reduced concentration ethanol (55%) with combination of other alcohols exhibiting a broad spectrum of virucidal activity

	Combination Product	70% ethanol	70% propanol
Lg RF	2.38	0.68	0.74

Interruption of Virus Transfer

- Artificially contaminated finger pads of volunteers (10 µl of inoculums, allowed to dry)
- Measured transfer of FCV from fingers to metal, ham and lettuce
- Compared “untreated” hands with those washed with water only; water and nongermicidal liquid soap; 62% alcohol and 75% alcohol



% Infectious Virus detectable on fingerpad

No treatment	71 ± 8.9
Water alone	8.6 ± 1.4
Soap and water	5.6 ± 1.3
62% Ethanol	13.8 ± 3.7
75% Ethanol	11.2 ± 2.8

Bidawid, S, J
Food Prot 2004:
67(1); 103-9)

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% Virus Recovered from Recipient Surface after Contact

	Ham	Lettuce	Metal disc	P value
No treatment	46.0 ± 20.3	18.0 ± 5.7	13.0 ± 3.6	
Water alone	0.9 ± 0.3	0.6 ± 0.1	0.5 ± 0.1	<0.003
Soap and water	0.6 ± 0.2	0.4 ± 0.1	0.5 ± 0.1	<0.004
62% ethanol	3.4 ± 0.9	2.1 ± 0.5	1.2 ± 0.2	<0.001
75% ethanol	2.3 ± 0.7	1.2 ± 0.3	0.7 ± 0.1	<0.001

Bidawid, S, J
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Oh, what to do, what to do???

➤ Conclusion:

- Ethanol based hand rubs are generally very useful in the decontamination of hands between handwashing and the somewhat lower activity of such agents against non-enveloped viruses such as FCV should not detract from their continued use by food handlers as well as healthcare personnel.



Hand Hygiene – the bottom line

- Handwashing is especially important before eating and after using the restroom
- In Norovirus outbreaks, alcohol-based hand sanitizers should be considered an adjunct to handwashing and not a replacement



Cleaning and Disinfection



- Environmental contamination is an issue
- Organism is resistant to quaternary ammonium compounds, sodium hypochlorite, peroxyacetic acid; iodine compounds
- Resistant to UV radiation and acidic pH



Cleaning, cleaning, cleaning



- Virus remains viable for prolonged periods. (4°C, >60 days; 20°C, 21-28 days).
- Contaminated shared bathrooms implicated on board ships
- Overcrowding in the ED with a build up of soiled bedpans and dirty linen implicated in a Toronto outbreak
- Need a comprehensive cleaning program!!!
- A terminal clean program should follow an outbreak



Factors

- Presence of fecal contamination decreases ability of products to eliminate virus
- One approach requires surface to be wiped clean with a detergent then apply a combination hypochlorite/detergent
- Otherwise, cleaning cloth can become a vehicle for spread of virus



DISINFECTANT LEVEL FOR VARIOUS PATHOGENS

PATHOGEN

DISINFECTANT LEVEL

Bacteria with spores Protozoa with cysts	Chemical Sterilant
Mycobacteria	High
Non-enveloped viruses Norovirus	Intermediate
Fungi	Intermediate
Vegetative bacteria	Low
Enveloped viruses Coronavirus	Low

Dr. Robert Wheeler

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Agents

- **Quats are not effective
- It has been suggested that double-strength phenolics may be effective
- Hypochlorite requires high concentrations to be effective (1000 ppm achieved 5.00 log₁₀ reduction in one minute)
- “accelerated, stabilized hydrogen peroxide”
.... Good activity against Feline calicivirus,
good success in outbreak management
aboard ships



	Hypochlorite	ASHP (0.5% HP solution)
Efficacy	Organic debris reduces effectiveness	Cleans and disinfects
Spectrum	Broad spectrum biocide	Broad spectrum biocide
Versatility	Used on hard, non-porous surfaces	environmentally safe
Ease of Use	Must be prepared daily	Concentrate, wet-wipes and RTU liquid
Safety profile	Damaging to many textiles, corrosive to metals, may produce toxic gas, irritating to persons	Non-toxic in RTU form
Cost	Inexpensive and readily available	Depends on format

Characteristics that facilitate Outbreak

TABLE 1. Characteristics of “Norwalk-like viruses” that facilitate their spread during epidemics

Characteristic	Observation	Consequences
Low infectious dose	<10 ² viral particles	Permits droplet or person-to-person spread, secondary spread, or spread by foodhandlers
Prolonged asymptomatic shedding	≤2 weeks	Increased risk for secondary spread or problems with control regarding foodhandlers
Environmental stability	Survives ≤10 ppm chlorine, freezing, and heating to 60 C	Difficult to eliminate from contaminated water; virus maintained in ice and steamed oysters
Substantial strain diversity	Multiple genetic and antigenic types	Requires composite diagnostics; repeat infections by multiple antigenic types; easy to underestimate prevalence
Lack of lasting immunity	Disease can occur with reinfection	Childhood infection does not protect from disease in adulthood; difficult to develop vaccine with lifelong protection

7 a.m.





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Conclusions



- Norovirus hits predictably in the winter season with sudden force and vengeance.
- You cannot reliably keep Norovirus out of your hospital or long term care facility.
- Prepare a plan for outbreak.
- Make sure you address cleaning and hand hygiene in your plan and in your education!!!





Thank you