Evidence-based prevention of infectious diseases in schools
-Part I: Fundamentals of infections in schools
-Part II: The importance of surface hygiene

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Outlines

✓ Overview of infectious diseases at school

✓ Fundamental principles of infectious diseases
  ▪ Basic and clinical microbiology
  ▪ Microbial pathogenesis
  ▪ Common pathogens and transmission pathways

✓ Evidence-based role of surface disinfection
  ▪ Hand hygiene
  ▪ Surface disinfection
Culprits of Infectious Diseases

Epidemiologically Significant Pathogens

- 28,502 HAIs reported to NHSN b/w Jan 2006-Oct. 2007
- 621 U.S. hospitals

EBOLA  MEASLES VIRUS

CDC 2010 report

http://www.slideshare.net/5alod/campbell-biology-9th-edition-slides
Microbial Resistance Profile to Disinfectants and Sterilants

More resistant

- Prions
- Endospores of bacteria
- Mycobacteria
- Cysts of protozoa
- Vegetative protozoa
- Gram-negative bacteria
- Fungi, including most fungal spores
- Viruses without envelopes
- Gram-positive bacteria
- Viruses with lipid envelopes

Less resistant

Peptidoglycan

Reference: Gerald E. McDonnell.
Antimicrobial Therapy

Goal: Seek to suppress or kill pathogenic microorganisms with minimal toxicity and/or side effects to the patient.

### How long can pathogens survive on environmental surfaces?

<table>
<thead>
<tr>
<th>Type of bacterium</th>
<th>Duration of persistence (range)</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter spp.</td>
<td>3 days to 5 months</td>
<td>[18, 25, 28, 29, 87, 88]</td>
</tr>
<tr>
<td><em>Bordetella pertussis</em></td>
<td>3 – 5 days</td>
<td>[89, 90]</td>
</tr>
<tr>
<td><em>Campylobacter jejuni</em></td>
<td>up to 6 days</td>
<td>[91]</td>
</tr>
<tr>
<td><em>Clostridium difficile</em> (spores)</td>
<td>5 months</td>
<td>[92–94]</td>
</tr>
<tr>
<td><em>Chlamydia pneumoniae, C. trachomatis</em></td>
<td>≤ 30 hours</td>
<td>[14, 95]</td>
</tr>
<tr>
<td><em>Chlamydia psittaci</em></td>
<td>15 days</td>
<td>[90]</td>
</tr>
<tr>
<td><em>Corynebacterium diphtheriae</em></td>
<td>7 days – 6 months</td>
<td>[90, 96]</td>
</tr>
<tr>
<td><em>Corynebacterium pseudotuberculosis</em></td>
<td>1–8 days</td>
<td>[21]</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>1.5 hours – 16 months</td>
<td>[12, 16, 17, 22, 28, 52, 90, 97–99]</td>
</tr>
<tr>
<td>Enterococcus spp. including VRE and VSE</td>
<td>5 days – 4 months</td>
<td>[9, 26, 28, 100, 101]</td>
</tr>
<tr>
<td><em>Haemophilus influenzae</em></td>
<td>12 days</td>
<td>[90]</td>
</tr>
<tr>
<td><em>Helicobacter pylori</em></td>
<td>≤ 90 minutes</td>
<td>[23]</td>
</tr>
<tr>
<td><em>Klebsiella spp.</em></td>
<td>2 hours to &gt; 30 months</td>
<td>[12, 16, 28, 52, 90]</td>
</tr>
<tr>
<td><em>Listeria spp.</em></td>
<td>1 day – months</td>
<td>[15, 90, 102]</td>
</tr>
<tr>
<td><em>Mycobacterium bovis</em></td>
<td>&gt; 2 months</td>
<td>[13, 90]</td>
</tr>
<tr>
<td><em>Mycobacterium tuberculosis</em></td>
<td>1 day – 4 months</td>
<td>[30, 90]</td>
</tr>
<tr>
<td><em>Neisseria gonorrhoeae</em></td>
<td>1 – 3 days</td>
<td>[24, 27, 90]</td>
</tr>
<tr>
<td><em>Proteus vulgaris</em></td>
<td>1 – 2 days</td>
<td>[90]</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>6 hours – 16 months; on dry floor: 5 weeks</td>
<td>[12, 16, 28, 52, 99, 103, 104]</td>
</tr>
<tr>
<td><em>Salmonella typhi</em></td>
<td>6 hours – 4 weeks</td>
<td>[90]</td>
</tr>
<tr>
<td><em>Salmonella typhimurium</em></td>
<td>10 days – 4.2 years</td>
<td>[15, 90, 105]</td>
</tr>
<tr>
<td><em>Salmonella spp.</em></td>
<td>1 day</td>
<td>[52]</td>
</tr>
<tr>
<td><em>Serratia marcescens</em></td>
<td>3 days – 2 months; on dry floor: 5 weeks</td>
<td>[90, 106, 107]</td>
</tr>
<tr>
<td><em>Shigella spp.</em></td>
<td>2 days – 5 months</td>
<td>[90, 108]</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em>, including MRSA</td>
<td>7 days – 7 months</td>
<td>[9, 10, 16, 52, 99, 108]</td>
</tr>
<tr>
<td><em>Streptococcus pneumoniae</em></td>
<td>1 – 20 days</td>
<td>[90]</td>
</tr>
<tr>
<td><em>Streptococcus pyogenes</em></td>
<td>3 days – 6 months</td>
<td>[90]</td>
</tr>
<tr>
<td><em>Vibrio cholerae</em></td>
<td>1 – 20 days</td>
<td>[90]</td>
</tr>
</tbody>
</table>
Norovirus (stomach bug)

### Setting of Norovirus Outbreaks Reported through the National Outbreak Reporting System (NORS), 2009–2010

<table>
<thead>
<tr>
<th>Exposure setting*</th>
<th>Number of Outbreaks</th>
<th>Percentage of Outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health care facility</td>
<td>932</td>
<td>63.7%</td>
</tr>
<tr>
<td>Restaurant or banquet facility</td>
<td>287</td>
<td>19.6%</td>
</tr>
<tr>
<td>School or day-care facility</td>
<td>98</td>
<td>6.7%</td>
</tr>
<tr>
<td>Private residence</td>
<td>31</td>
<td>2.1%</td>
</tr>
<tr>
<td>Other single setting</td>
<td>114</td>
<td>7.8%</td>
</tr>
</tbody>
</table>

*Restricted to outbreaks with a single exposure setting (N=1,462).*

Data on specific settings are restricted to outbreaks with a single exposure setting. For foodborne outbreaks, “setting” refers to the setting where implicated food was consumed.

http://www.cdc.gov/features/dsnorovirus/figure2.html

http://spacecoastdaily.com/2014/06/the-new-norovirus-from-down-under/
Traditional Norovirus transmission pathways

- Infected food-handler
- Person to person
- Animal reservoir
- Shellfish
- Environmental contamination
- Food: raspberries, salads, sandwiches
- Water
Transmission pathways can be bridged from indirect (fomite surface) to direct (mucus membrane, GI tract, etc.)
Transmission pathways can be bridged from indirect (fomite surface) to direct (mucus membrane, GI tract, etc.)
Hand hygiene is significantly compromised if the environmental surfaces are not clean.

**Figure 1** Sequential finger transfer of NV to clean melamine surfaces after initial contamination of fingers with faecally contaminated toilet tissue (four replicate tests).
Summary A reverse transcriptase polymerase chain reaction assay was used to study the transfer of Norovirus (NV) from contaminated faecal material via fingers and cloths to other hand-contact surfaces. The results showed that, where fingers come into contact with virus-contaminated material, NV is consistently transferred via the fingers to melamine surfaces and from there to other typical hand-contact surfaces, such as taps, door handles and telephone receivers. It was found that contaminated fingers could sequentially transfer virus to up to seven clean surfaces. The effectiveness of detergent- and disinfectant-based cleaning regimes typical of those that might be used to decontaminate faecally contaminated surfaces and reduce spread of NV was also compared. It was found that detergent-based cleaning with a cloth to produce a visibly clean surface consistently failed to eliminate NV contamination. Where there was faecal soiling, although a combined

From indirect (fomite surface) to direct (mucus membrane, GI tract, etc.)
Environmental transmission of norovirus gastroenteritis

Ben Lopman¹, Paul Gastañaduy¹,², Geun Woo Park¹, Aron J Hall¹, Umesh D Parashar¹ and Jan Vinjé¹

The advent of molecular techniques and their increasingly widespread use in public health laboratories and research studies has transformed the understanding of the burden of norovirus. Norovirus is the most common cause of community-acquired diarrheal disease across all ages, the most common cause of outbreaks of gastroenteritis, and the most common cause of foodborne disease in the United States. They are a diverse group of single-stranded RNA viruses that are highly infectious and stable in the environment; both symptomatic and asymptomatic infections are common. Through shedding in feces and vomit, norovirus can be transmitted directly through an array of routes: person-to-person, food or the environment. The relative importance of environmental transmission of virus is yet to be fully quantified but is likely to be substantial and is an important feature that complicates control.

England and The Netherlands have estimated incidence in the general population between 4.1 and 4.6 cases per 100 person-years [2,3*], with regional studies providing generally consistent results [4,5]. Incidence is approximately 5 times higher in children under the age of five years [5]. In the United States, norovirus causes an estimated 21 million cases of acute gastroenteritis [6] and >70 000 hospitalizations annually across all age groups [7]. The burden of disease increases considerably in years where novel genogroup II genotype 4 variants emerge, with hospitalizations surging by approximately 50% [8–10]. Although symptomatic norovirus infections are usually mild and self-limiting in otherwise healthy adults, they may be fatal among the elderly [11] and immunocompromised persons [12]. Excess mortality associated with norovirus has been documented in a
Transmission pathways can be bridged

Figure 1 Routes of transmission of norovirus from infected to uninfected people.

Norovirus transmission can occur via a range of transmission routes. Characteristics and behaviors of the infected host and potential susceptibles may mitigate the risk of transmission. This simple schematic is not meant to depict all the intricacies of each pathway, but rather to highlight the interaction of the various routes and to illustrate that all pathways require shedding of virus from infectious hosts. Different control measures may be targeted at each arrow; here, the role of environmental disinfection is highlighted. Certain practices (such as hand hygiene) may reduce transmission through all pathways while targeted interventions (such as exclusion of ill food handlers from work) may reduce transmission through specific pathways.
Environmentally-mediated transmission can last much longer than direct transmission.
Important of environmental disinfection


**Figure 2:** Distribution of *S. aureus* on body sites of the general population and of nasal carriers.
Hand hygiene is important, but wait……

How many times do we touch our faces during one hour?

Please choose one of the following answers.

A. 0-3

B. 4-7

C. 8-11

D. More than 11
Hand hygiene is important, but wait......

How many times do we touch our faces during one hour?

Alonso and colleagues randomly selected 249 people in public places, on the Washington, D.C. subway and in the Brazilian city of Florianopolis. The researchers observed them, noting how often they touched a common surface and then their mouth or nose. They found that people touched their faces an average of 3.6 times per hour, and common objects an average of 3.3 times per hour.

This rate of self-touching means that people likely get germs on their hands much more frequently than they wash germs off their hands, according to the study[1].

By touching the surfaces, transmission pathways (direct & indirect) are bridged

How many times do we check our cell phones *in one day*?

Please choose one of the following answers.

A. 0-40
B. 41-80
C. 81-120
D. More than 120
How many times do we check our cell phones in one day?

A study by Kleiner Perkins Caufield and Byers found the average user checks their phone nearer to **150 times** per day. In its annual Internet Trends report, carried out in May this year, found that people check their phones, on average, **23 times** a day for messaging, **22 times** for voice calls and **18 times** to get the time.

By doing so, we complete the pathogen exchange between hands and environmental surfaces.

Role of environmental surfaces in infectious disease transmission

Review article

Lifting the lid on toilet plume aerosol: A literature review with suggestions for future research

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Role of environmental surfaces in infectious disease transmission

Viral infections acquired indoors through airborne, droplet or contact transmission

Giuseppina La Rosa, Marta Fratini, Simonetta Della Libera, Marcello Iaconelli and Michele Muscillo
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Importance of surface hygiene in infectious disease transmission

Methods of Transmission

- Airborne
- Direct contact (Hands)
- Fomites (Contaminated Surfaces)

Hand Hygiene
Surface Hygiene
Laundry, Hard and Porous Surfaces
Sub-micron Air filtration

How does your current cleaning program deal with the threat of MRSA?

Evidence-based norovirus infections

Key message: Environmental surfaces can bridge transmission pathways and play a key role in spreading of infectious diseases
Can surface disinfection and hand hygiene prevent all infectious diseases?

Many of them, but **not all of them**. For example, TB. Tuberculosis (TB) is caused by a bacterium called *Mycobacterium tuberculosis*. TB is spread through the air from one person to another. TB is **NOT spread** by:

- shaking someone's hand
- sharing food or drink
- touching bed linens or toilet seats
- sharing toothbrushes
- kissing

CDC suggests a three-level hierarchy of control measures:
1. Administrative measures: reduce the risk of uninfected people who are exposed to people who have TB disease
2. Environmental controls: reduce the amount of TB in the air
3. Use of respiratory protective equipment: use of respiratory protective equipment in situations that pose a high risk of exposure to TB

TB is preventable, treatable and curable, but not through environmental surfaces.

http://www.cdc.gov/tb/topic/basics/
Increasing public health threat due to antibiotic resistance

Estimated minimum number of illnesses and deaths caused annually by antibiotic resistance*:
At least 2,049,442 illnesses, 23,000 deaths

* bacteria and fungus included in this report

Rise of Antibiotic Resistance in Various Common Infections

MRSA = methicillin-resistant *Staphylococcus aureus*; VRE = Vancomycin-resistant enterococci; FQRP = Fluoroquinolone-resistant *Pseudomonas aeruginosa*

CDC data

CDC: Cleaning and disinfecting are part of a broad approach to preventing infectious diseases in schools

- **Know the difference between cleaning, disinfecting, and sanitizing**
  - Cleaning removes germs
  - Disinfecting kills germs
  - Sanitizing lowers the number of germs

- **Know the difference between cleaning, disinfecting, and sanitizing**
  - Daily sanitizing surfaces and objects that are touched often, such as desks, countertops, doorknobs, computer keyboards, hands-on learning items, faucet handles, phones, and toys. Some schools may also require daily disinfecting these items. **Standard procedures often call for disinfecting specific areas of the school, like bathrooms, door handles**
  - Immediately clean surfaces and objects that are visibly soiled with PPE.

- **Simply do routine cleaning and disinfecting** (school staff should not be allowed to bring in their own disinfectant products for safety, proper use reasons.)

- **Clean and disinfect correctly**
  - Use an EPA-registered disinfectant to kill germs

- **Know your products and use products safely**
Professionally trusted brand

Available at www.schoolhealth.com
Jointed efforts towards prevention of infectious diseases

Complex, multiple actives

- Size, shape, charge, binding affinity, kinetics, residual effects
- Stability, aesthetics (odor, appearance, etc.)
- Safety and compatibility

Mechanistic understanding

Evidence-based knowledge + Product + Practice
Questions?
Thank you!

Metrex
Protecting People