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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✓ 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
Infectious diseases account for millions of school days lost each year for kindergarten through 12th-grade public school students in the United States\(^1\)

40% of children aged 5–17 years missed 3 or more school days in the past year because of illness or injury\(^2\)

Nearly 22 million school days are lost each year due to colds alone\(^3\)

38 million school days are lost each year due to the influenza virus\(^3\)

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1. CDC. Infectious diseases at school
Classification

- Virus (Smallest infectious agent-DNA or RNA in a protein coat)
- Bacteria (single-cell prokaryotes)
- Fungi (Eukaryotic organisms with cell walls that lack photosynthetic capability)
  - Yeast
  - Mold
- Prions (Infectious agent composed of protein)
- Parasites
  - Bedbugs, lice
  - Protozoa (unicellular, free-living eukaryotic organisms)
<table>
<thead>
<tr>
<th>Species name</th>
<th>Source of Genus Name</th>
<th>Source of Specific Epithet</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Klebsiella pneumoniae</em></td>
<td>Honors Edwin Klebs</td>
<td>The disease</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>Honors Theodor Escherich</td>
<td>Derived from the colon, an inhabitant in gastro-intestinal tract</td>
</tr>
<tr>
<td><em>Salmonella typhimurium</em></td>
<td>Honors Daniel Salmon</td>
<td>Stupor (<em>typh</em>-) in mice (<em>muri-</em>)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>Greek staphyle, <em>meaning</em> a bunch of grapes, and kokkos, <em>meaning</em> berry</td>
<td>Gold-colored (<em>aureus</em>) colonies</td>
</tr>
</tbody>
</table>

Genus name: May be descriptive or honor a scientist. The species name includes the genus as well as the specific epithet.

- Italicized or underlined
- Genus name is capitalized and may be abbreviated
- A genus name may be used alone to indicate a genus group; a species name is never used alone
  eg: *Bacillus subtilis*  
  *B. subtilis*
Culprits of Infectious Diseases

Epidemiologically Significant Pathogens

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

CDC 2010 report

Ebola
Measles virus

http://www.slideshare.net/5alod/campbell-biology-9th-edition-slides

@Pearson Education/Benjamin Cummings
Culprits of Infectious Diseases


• **Virus size**
  - 17 nm – 3000 nm diameter

• **Basic shape**
  - Rod-like
  - “Spherical”

• **Protective Shell - Capsid**
  - Made of many identical protein subunits
  - Symmetrically organized
  - 50% of weight
  - Enveloped or non-enveloped

• **Genomic material**
  - DNA or RNA
  - Single- or double-stranded

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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.
Basic and clinical microbiology

Techniques used to identify microbes

- Direct on microbes
  - Biochemistry
    - Gram staining, acid-fast staining
    - Culture (Growth media, incubation parameters)
    - Differential testing (biochemical responses, carbohydrate fermentation, enzyme testing)
    - Antigen detection (ELISA, serological testing, latex agglutination, MIP)

Specific color reactions of microorganisms on CHROMagar Orientation.
1. *P. mirabilis*
2. *E. faecalis*
3. *K. pneumoniae*
4. *P. aeruginosa*
5. *E. coli*
6. *S. aureus*

**Chromogenic media**
- Contains chromogenic substrate such as ONPG, X-Gal, X-Glu
- The substrate can only be metabolized by certain enzymes
- The enzymes are specific to target microbes
- Direct observation of a distinct color change in the medium

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Pathogenic organisms, e.g. bacteria, virus (AFM image of pathogenic *E. coli*)

**Phenotypic diagnosis**
- Significant delay and inaccuracy

**Fluorescent diagnosis**
- Complex steps (stain, wash, image....)

**Biochemical diagnosis**
- Too specific and costly

**Immunological diagnosis**
- Hard to determine the "cut-off" point between a positive and negative result

**Nucleic acid amplification based diagnosis**, e.g. PCR

**Polymerase Chain Reaction (PCR)**

**Surface based hybridization**

**Overview of Microbial Diagnostics**

DNA/RNA hybridization based molecular diagnostics

Liu, Y. et al., *Analytical Biochemistry*. Charge-neutral morpholino microarrays for nucleic acid analysis. 2013, 434 (2) 207-214
Infection elements

Source: CDC
Pathogenicity

– Ability of a microorganism to cause disease by overcoming the defenses of a host

Virulence

– The degree or extent of pathogenicity
How Microorganisms Cause Disease

Transmission

- Direct contact: close physical contact
- Indirect contact: transmission by fomites
- Droplet transmission: coughing or sneezing
- Vehicle transmission: via a medium (water, food, air, etc.)

http://www.sciencephoto.com/
Portals of Entry

Pathogens

- Must gain access to host
- Adhere to host tissue
- Penetrate or evade host defenses
- Damage host tissue
Portal of Entry

- Routes microorganisms can penetrate the body
  - 1- mucous membranes
  - 2- skin
  - 3- parenteral route
Mucous membranes

- Respiratory tract
  - Easiest and most frequent route of infection
  - Inhaled through nose or oral cavity
  - Duct particles, moisture droplets
  - Common cold, pneumonia, tuberculosis, influenza, smallpox and measles
Mucous membrane

- Gastrointestinal route
  - In food or water
  - Contaminated fingers
  - Most are inactivated by stomach acid, enzymes
  - *Norovirus, Salmonella, hepatitis A, cholera*
Mucous membrane

- Genitourinary tract
  - Contracted sexually
  - Intact or broken mucous membranes
  - STD (sexually transmitted diseases/infections)
  - HIV, genital warts, genital herpes, syphilis, and gonorrhea
Skin

- Unbroken skin – barrier to microorganisms
- Abscesses, burns, wounds, bites
- A reservoir
Some microbes must enter via preferred route to cause disease

- *Streptococcus pneumoniae*
  - if inhaled can cause pneumonia
  - if enters the G.I. Tract, no disease

- *Salmonella typhi*
  - if enters the G.I. Tract can cause Typhoid Fever
  - if on skin, no disease

Some microbes may cause disease with many different route of entry

- *Pseudomonas aeruginosa*
Transmission of Measles

- Measles is a highly contagious virus that lives in the nose and throat mucus of an infected person.

- It can spread to others through coughing and sneezing.

- Also, measles virus can live for up to two hours on a surface or in an airspace where the infected person coughed or sneezed.

- If other people breathe the contaminated air or touch the infected surface, then touch their eyes, noses, or mouths, they can become infected.

- Measles is so contagious that if one person has it, 90% of the people close to that person who are not immune will also become infected.

- Infected people can spread measles to others from four days before to four days after the rash appears.

- Measles is a disease of humans; measles virus is not spread by any other animal species.

Reference: CDC. Measles.
<table>
<thead>
<tr>
<th>Specific adherence</th>
<th>Non-specific adherence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ligand-receptor interactions</strong></td>
<td>• Liftshitz-van der Waals</td>
</tr>
<tr>
<td></td>
<td>• Electrostatic interactions</td>
</tr>
<tr>
<td></td>
<td>• Lewis acid/base interactions</td>
</tr>
<tr>
<td></td>
<td>• Hydrophobic/lipophilic-mediated adhesion</td>
</tr>
<tr>
<td></td>
<td>• Hydrophobic structure on microbial cell envelope</td>
</tr>
<tr>
<td></td>
<td>• Lipophilic area on host cell membrane</td>
</tr>
</tbody>
</table>
## Adherence/Attachment

<table>
<thead>
<tr>
<th>Microbial adhesion</th>
<th>Host cell receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uropathogenic <em>E. coli</em> P pili (fimbriae)</td>
<td>Epithelial cells glycolipid receptor globobiose</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> fibronectin binding protein</td>
<td>Epithelial, endothelial, fibroblastic cells fibronectin receptor integrin</td>
</tr>
<tr>
<td><em>Norovirus</em> P domain of the capsids</td>
<td>Epithelial cells (food, direct contact, fomites) human histo-blood group antigens (HBGAs)</td>
</tr>
<tr>
<td>Influenza hemagglutinin (H) protein</td>
<td>Upper respiratory tract Sialic acid on host membranes</td>
</tr>
</tbody>
</table>

**Hemagglutinin**: >18 subtypes  
**Neuraminidase**: > 11 subtypes

<table>
<thead>
<tr>
<th>Infection category</th>
<th>Examples</th>
<th>Pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach &amp; Intestinal Infections</td>
<td>Stomach flu vs. food poisoning</td>
<td>Diarrhea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Salmonella, Norovirus</td>
</tr>
<tr>
<td>Lung &amp; Respiratory infections</td>
<td>Infection vs. asthma (inflammation of the airways)</td>
<td>Cold; flu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rhinovirus, coronavirus, RSV; Influenza A, B; Measles viruses</td>
</tr>
<tr>
<td>Skin Infections &amp; Rashes</td>
<td><img src="image" alt="Scarlet fever" /></td>
<td>Scarlet fever (strep throat with a rash)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Streptococcus pyogenes</td>
</tr>
<tr>
<td>Eye Infections</td>
<td><img src="image" alt="Conjunctivitis" /></td>
<td>Conjunctivitis (pinkeye)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Viruses or bacteria Staphylococcus, Pseudomonas</td>
</tr>
<tr>
<td>Ear Infections</td>
<td><img src="image" alt="Middle Ear Infections" /></td>
<td>Middle Ear Infections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Streptococcus, Respiratory syncytial virus (RSV) Influenza</td>
</tr>
</tbody>
</table>

http://kidshealth.org/parent/infections/
Healthwise; Mayo Foundation for Medical Education and Research
Goal: Seek to suppress or kill pathogenic microorganisms with minimal toxicity and/or side effects to the patient.

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
Schools inherently foster the transmission of infections from person to person because they are a group setting in which people are in close contact and share supplies and equipment.

In order to cut the transmission pathways, good practices include:

- Encouraging sick students and staff to stay home and seek medical attention for severe illness.
- Facilitating hand hygiene by supplying soap and paper towels and teaching good hand hygiene practices.
- Being vigilant about cleaning and disinfecting classroom materials and surfaces.
- Providing messages in daily announcements about preventing infectious disease.
- Adopting healthy practices such as safe handling of food and use of standard precautions when handling body fluids and excretions.
- Encouraging students and staff to get annual influenza vaccinations, measles vaccine.

http://www.cdc.gov/healthyyouth/infectious/
Questions?
Thank you!