Worker Protection, Hazard Analysis, and Risk of Infectious Agents

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HAZARD ANALYSIS

Emergence of New Infectious Diseases

- SARS-2002- Asia, global
- Chikungunya-2004-Africa, Asia (Now Americas)
- H1N1 influenza-2009-Mexico7,global
- MERS-2012-Saudia Arabia, Korea
Three Things Needed for Transmission of Infectious Agent:

- Source of Infection (e.g., infected individual)
- Route of Transmission
- Susceptible Population

“Ecology of Disease Transmission”

How Infectious Diseases Emerge

- Change in host
- Change in exposure
- Change in pathogen
- Novel recognition (Change in methods)

“Change in Ecology”

Ebola

Scientific Classification

- Order: Mononegavirales
- Family: Filoviridae
- Genus: Ebolavirus
- Species:
  - Bundibugyo ebolavirus (Uganda)
  - Reston ebolavirus (Philippines)
  - Sudan ebolavirus (Sudan)
  - Tai Forest ebolavirus (Cote de Ivoire)
  - Zaire ebolavirus (Zaire)

Ebola Virus

- First appeared in Africa 1976
- “African Hemorrhagic Fever”
  - Acute, mostly fatal disease
  - Causes blood vessel “bursting”
  - Systemic (all organs/tissues)
  - Humans and nonhuman primates
- Excluding 2000 outbreak
  - 1,500 cases
  - Over 1,000 deaths
- Current West Africa Outbreak
  - 28,608 total cases (half confirmed) with more than 11,000 deaths in three hardest hit countries
  - 36 exported cases in 7 countries with 15 deaths, including 4 confirmed cases to United States with 1 death.
Coronaviruses

- Irregularly shaped
  - 60-220 nm diameter
- +ssRNA genome (27-31 kb)
- Enveloped particles with loosely wound nucleocapsid
  - characteristic “club-shaped” peplomers
- 10% of Common colds
- Four major groupings:
  - Alphacoronavirus
  - Betacoronavirus
  - Gammacoronavirus
  - Deltacoronavirus
  - wide host range
  - mostly avian

Severe Acute Respiratory Syndrome (SARS)

MERS-CoV

- The first confirmed case was reported in Saudi Arabia 2012
- As of July 2015, MERS-CoV cases have been reported in over 21 countries
- Sustained human to human transmission appears to be low
- Originated in Bats; Camels are a reservoir
- High case fatality rate (15-60%)
  - 44% in Saudi Arabia
Influenza Viruses

• Pleomorphic, spherical filamentous forms occur
  – 50-120 nm diameter, or 20 nm diameter and 200-300 nm long
• Segmented, linear -ssRNA genome
  – 7 to 8 segments
• Enveloped, filamentous nucleocapsids
  – Envelope is lipid bilayer with ~500 spikes for attachment
  • Hemagglutinin
  • Neuraminidase
• Causes “the flu”

Genus: Enterovirus

• Icosahedral shape, ~27-30 nm diameter
• Single-stranded +sense RNA
  – about 7,500 nucleotides
• Icosahedral protein coat (capsid)
  – 4 capsid proteins: VP1, VP2, VP3, VP4
  (all cleaved from VP0)
• 10 viral species (>100 subtypes)
  – Enterovirus A
  – Enterovirus B
  – Enterovirus C (Polioviruses)
  – Enterovirus D
  – Enterovirus E (Bovine enterovirus A)
  – Enterovirus F (Bovine enterovirus B)
  – Enterovirus G (Porcine enterovirus B)
  – Enterovirus H (Simian enterovirus A)
  – Enterovirus J
  – Rhinovirus A
  – Rhinovirus B
  – Rhinovirus C

EV-D68

• Circulating in US since 1987
• Nationwide outbreak began in August 2014
  – From Aug 2014 to middle of Jan 2015, a total of 1,153 people in 49 states and the District of Columbia confirmed with EV-D68
  – Likely millions of additional mild cases
  – detected in specimens from 14 patients who died
Managing Risks in Infection Control

- Perceive the risk
- Risk Assessment
- Cost Benefit Analysis
- Risk Management
- Controls
- Monitor
- Risk Communication

Risk Perception

- Cultural Theory
  - Two axes:
    - Influence of the group on social relationships
    - Degree of constrainment by rules
  - Four classifications of individuals
    - Fatalists: little control
    - Hierarchists: rank risks
    - Individualists: decisions left to individual
    - Egalitarians: based on consensus
Where do Healthcare Personnel Fall with Regard to Risk Perception?

“The conclusions of our study indicate that public health organizations must consider the fact that health professionals are a group that cannot be automatically treated as an extension of the organization. When the risk is tangible and relevant, health care workers behave and act like everybody else: they mix intuition and emotions with analytical analysis, creating a complex risk perception with an optimistic bias.”

Risk Perception (Fright Factors)

• Less Acceptable if:
  – Involuntary
  – Inequitable
  – Inescapable
  – Unfamiliar
  – Man-made
  – Effects delayed
  – Threat to future generations
  – Particularly severe or dreadful effect
  – Poorly understood by science
  – Affects identifiable individuals
  – Subject to contradiction by responsible sources

Microbial Risk Assessment

• Different approaches in different fields
• Most follow same basic framework
  – Hazard ID
  – Exposure Assessment
  – Health Effects Assessment
  – Risk Characterization
• Approach used may range from simple qualitative assessment to risk ranking to quantitative assessments
  – Will depend on circumstances under which assessment conducted and available information
Considerations for Microbial Risk Assessments

- A single microbe (one unit) may be infectious
- Microbes may multiply:
  - In a host
  - In environmental media (some, but ...)
- Secondary spread
  - A case can be a source
  - Direct or Indirect

As for all risk assessments
- Host Behaviors Matter

Conducting Hazard Identification

- Identify microbes as causative agent of disease
- Understand the disease process from exposure to infection, illness (pathophysiology) and death
- Identify and understand transmission routes
Routes of Transmission

- Confusion?????
  - Person to Person
  - Fecal-Oral
  - Respiratory/Airborne/Aerosol/droplet
  - Fomitic or Surface-related

Routes

- Route of Exposure
  - How it enters the host

- Route of Shedding
  - How it exits the host

- Route of Transmission
  - Route of exposure, vehicle or vector, route of exit
Exposure Assessment
• Purpose: determine the dose
• A few things to consider:
  – Source/Shedding levels
  – Survival and multiplication of the microorganism
  – Routes of exposure and transmission potential
  – Duration and multiplicity of exposures
  – Susceptibility and behavior of exposed population
  – Efficacy of Controls
    • including their reliability and variability

Health Effects Assessment
• Purpose: determine the response from exposure
• A few things to consider:
  – Disease characteristics and spectrum of health outcomes
  – Infectivity and Dose Response
  – Secondary spread

Dose-Response Data
and Probability of Infection for Human Rotavirus

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<th># Infected</th>
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Acceptable Risk
• Are there acceptable risks?
  – If so, how are they defined?
  – Acceptable vs. Accepted
• Nature of Risk
  – Zero risk of infection doesn’t exist except in absence of pathogen
  – Full spectrum of risk
WORKER PROTECTION

Administrative Controls

• OSHA
  – General Duty Clause
  – Bloodborne Pathogen Rule
• CDC Guidelines and Recommendations
• Institutional Procedural Controls
  – Training and Simulations
  – Strategic breaks
  – Infection control and Occupational Health
  – Documentation
PERSONAL PROTECTIVE EQUIPMENT (PPE)

Worker protection

**Current CDC PPE Recommendations**

- **PPE Type**
  - Respiratory protection
  - Gowns, Coveralls, & Aprons
  - Gloves
  - Boots and Covers
- **Donning**
- **Doffing**
- **Observers**
- **Designated Areas**
- **Training on Correct Use**

**Advanced PPE**

**Basic PPE**

**Suit Up Components**

- Splash and Chemical Resistant Suit
- Apron w/Stirrups
- Disposable Scrubs
- Hat and Cap
- Goggles
- Surgical Mask
- Boot and Covers
- Foot PPE Respirator
Gloves - caveats

• No glove is good against all hazards; consult laboratory safety link on EHS web page for glove selection chart
• Gloves have a finite lifespan and must be periodically replaced
• When donning gloves, examine them for signs of tears, cracks, holes and dry rot
• Hands should always be washed after removing gloves

Choosing the Right Glove

• Determine the Hazard (Check MSDS first)
  – Chemical Hazard
  – Biological Hazards
  – Radioactive Hazards
  – Sharps Hazards
  – Combination Hazard
• Other things to consider
  – Chemical concentrations, temperatures, exposure time
  – Allergies
  – Length type of cuff
  – Sizing and Handedness
  – Use and Disposal

Respiratory Protection

• N-95 respirator
• Air Purifying Respirators (APR)
  – Half-face
  – Full Face
• Powered Air Purifying Respirators (PAPR)
• Pressurized Suits

Facial hair...

• The respirator cannot form a tight seal against the cheeks and chin, resulting in air leaks which can allow airborne contaminants to be inhaled
• Specially designed PAPR hoods can be used for employees with facial hair
• Small amounts of facial hair that fit inside of the respirator facepiece are acceptable
Fit Testing
Before an employee uses any respirator with a negative or positive pressure tight-fitting facepiece, the employee must be fit tested with the same make, model, style, and size of respirator that will be used.

Qualitative Fit Test (QLFT)
A pass/fail fit test to assess the adequacy of respirator fit that relies on the individual’s response to the test agent.

Quantitative Fit Test (QNFT)
An assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.

Worker protection
CONTAINMENT
Spills

- Contain first
  - Absorbent pads
  - Gelling agents
- Decontaminate
  - Powdered disinfectant
  - Disinfectant choice
- Clean
- Disinfect
  - Disinfectant choice

Waste Decontamination

- Waste contaminated with a Category A infectious substance is regulated as a hazardous material (USDOT)
- Appropriate Decontamination
  - Autoclaving
  - Incineration
- However, waste that has been appropriately incinerated, autoclaved, or otherwise inactivated is not infectious, does not pose a health risk, and is not considered to be regulated medical waste or a hazardous material under federal law.

Factors to Consider

- The intended vs. labeled use of the disinfectant
- Target microorganisms
- Concentration and Time
- The media to be treated
- Presence of interfering materials in the media

Worker protection

(CHEMICAL) DISINFECTANTS
### Spalding Hierarchy


### Common Surface Disinfectants
- **Surface-active agents (Quats)**
- **Phenolic compounds**
- **Peroxygen compounds**
- **Chlorine species (free chlorine, chloramines)**
- **Chlorine dioxide**

### Quaternary ammonium compounds
- **Mechanism:** Protein denaturation, enzyme inhibition, and disruption of cytoplasmic membrane
- **Advantages**
  - Low toxicity
  - Low corrosivity
  - Stable at high temperature and wide pH range
  - Relatively tolerable with organic load
- **Disadvantage**
  - Not effective against viruses, protozoa, and spores
  - Less effective at low temperature
  - Inhibited by most anionics and hard water salts

### Phenol compounds
- **Mechanism**
  - Bacteria: denaturation of proteins, inhibition of enzymes, damages on plasma membrane
  - Viruses and fungi: Unknown
- **Advantages**
  - Effective against viruses, bacteria, and fungi
  - Stable in concentrate
  - Tolerable for organic load and hard water
- **Disadvantages**
  - Not effective against spores
  - High toxicity
  - Not effective at low temperature
  - Incompatible with nonionic and cation surfactants
Peroxygen compounds

- Mechanism: hydroxyl radicals target proteins, lipids, and DNA
- Advantages
  - Strong, fast-acting
  - Effective against most microbes including spores
  - No toxicity
  - No environmental concern
  - Effective over wide pH (up to 7.5) and temperature ranges (40 °F – 150 °F)
  - Stable in concentrate
  - Tolerable for organic load
- Disadvantages
  - Limited stability at use solution (low concentration)
  - Corrosive on soft surfaces (brass, copper, and mild and galvanized steel)
  - Expensive

Free chlorine: advantages and disadvantages

- Mechanism: Oxidation
- Advantages
  - Effective against (almost) all types of microbes
  - Relatively simple maintenance and operation
  - Inexpensive
- Disadvantages
  - Corrosive
  - High toxicity
  - High chemical hazard
  - Highly sensitive to inorganic and organic loads
  - Formation of harmful disinfection by-products (DBP’s)

Chloramines: advantages and disadvantages

- Mechanism: weak oxidant
- Advantages
  - Less corrosive
  - Low toxicity and chemical hazards
  - Relatively tolerable to inorganic and organic loads
  - No known formation of DBP
  - Relatively long-lasting residuals
- Disadvantages
  - Not so effective against viruses, protozoan cysts, and bacterial spores

Chlorine dioxide: advantages and disadvantages

- Mechanism: Strong Oxidant
- Advantage
  - Very effective against (almost) all type of microbes
- Disadvantages
  - Unstable (must be produced on-site)
  - High toxicity
    - $2\text{ClO}_2 + 2\text{OH}^- \rightarrow \text{H}_2\text{O} + \text{ClO}_3^- + \text{ClO}_2^-$ (Chlorate) + (Chlorite): in alkaline pH
  - High chemical hazards
  - Highly sensitive to inorganic and organic loads
  - Formation of harmful disinfection by-products (DBP’s)
  - Expensive
Selection criteria (chemical antimicrobial agents)

- Antimicrobial efficacy
- Stability
- Corrosivity
- Chemical hazard

Biocidal spectrum

Stability

Corrosivity

FIG. 23.4. Typical use solution stability profiles ranges of commercial sanitizers and disinfectants containing various antimicrobial chemical agents.

FIG. 23.3. Relative comparison of metal, plastic, and elastomer corrosivity profile ranges of typical use solutions of commercial sanitizers and disinfectants containing various antimicrobial chemical agents.
Chemical hazard

FIG. 23.1. Relative comparison of chemical hazard profile ranges of typical product concentrates and diluted use solutions of commercial sanitizers and disinfectants containing various antimicrobial chemical agents.