Air & Water Sanitation for Infection Control and Prevention
Andrew Streifel, University of Minnesota
A Webber Training Teleclass

2008 Training Program

- Developed for managing emerging infectious diseases-MN Dept of Health
- Topics for hospital infection control
  - Temporary Negative Pressure Isolation
  - Instrumentation for objective analysis
  - Sanitation of body substances
- 60 minute presentation

Goals of Program

- Understand the role of the environment for infection control during infectious disease events
- Provide guidance for management of every day infectious disease incidents
- Preparation for emerging infectious disease event

Objectives

- Demonstrate containment of aerosols
  - During infectious disease event
  - Everyday events for maintenance and construction
- Provide sanitation training for body substance
  - Emerging infectious disease preparedness
    - Cleanup of body substances from infectious patients
    - Cleanup after plumbing maintenance
    - Validation of event cleanup
      - Real-time surrogate microbial measurement

CDC Environmental Infection Control Guidelines 2003

Old fashioned way of isolating patients
Lack of ventilation control

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Hospital survey summary of Airborne Infection Isolation Capability

- 678 rooms surveyed using survey and site visit objective analysis
- Most rooms do not meet AIA/CDC criteria
- Inadequate pressures in a large % of rooms checked
- Filtration analysis less than specification in a high % of air handlers checked
- Lack of written plans for negative pressure machines and surge management


Breaking the Chain of Infection

- Temporary Negative Pressure Isolation
  - Isolate infectious microbe to eliminate the mode of transmission

- Sanitation
  - Direct removal of infectious pathogen from reservoir
  - Change of pathogenic reservoir environment in order to inhibit and prevent its growth

Introduction to Ventilation

- Definition of Terms
  - Negative pressure: air from clean to dirty with airflow into the room being used to isolate a airborne infectious agent.
  - Air exchange rate: the rate at which the room air exchanges every hour. For each air exchange particles are reduced theoretically by 66%.
  - Filtration efficiency: the rate at which particles are removed according to particle size.
  - Droplet nuclei: small particles (1-5µm in diameter) able to remain airborne indefinitely and cause infection when exposed at or beyond 3 feet of the source of these particles.
  - Inhalation transmission: infectious particles at greater than 6 feet (2 meters) from the patient.
Purpose of Temporary Negative Pressure Isolation (TNPI)

- Meet surge capacity for patient isolation in response to pathogenic event
- Construction project infection control
- Prevent infectious particles from escaping the room envelope
  - Pressure management (>2.5 Pascal)
  - Dilution ventilation (12 air exchanges/hr)
  - Filtration (>90% efficient)

What is TNPI used for today?

- Construction
  - Hospitals are being updated and aerosols are released
- ID isolation
  - Airborne infectious disease should be controlled with clean to dirty airflow
- Surge isolation
  - Prepared to handle many infectious patients

How to validate negative pressure isolation rooms

- Types of NPI
  - Rooms
    - Permanent setting with controls & monitoring
    - Temporary rooms
  - Surge control areas
    - Select areas in hospital for sudden increase in patients
    - Should be relatively modern with ventilation controls
  - Local isolation
    - Temporary set-up for short term

What to validate: Ventilation Control

- Airflow direction
  - Clean to dirty airflow
  - When is the patient considered clean?
  - When is the patient contaminated?

Creating TNPI with Portable HEPA Filter

What conditions are needed to create airflow control

Discharge to: Outside Air

Steps for discharging air to the outside
1. Select a room
2. Set up pre-constructed window adapter
3. Set up HEPA machine and flex duct
4. Seal return air grille
5. Turn on HEPA machine and adjust flow

Create airflow into the patient room while extracting filtered air.
Discharge to: Return Air System

Steps for discharging air to return air system
1. Select a room
2. Attach flex duct adapter to desired return grille
3. Set up HEPA machine and flex duct
4. Seal remaining air grilles
5. Turn on HEPA machine and adjust flow

Create airflow into the patient room while extracting filtered air.

Proof of Containment

- Barriers for containment must show pressure differential (sides pull in as if under a vacuum)
- Differential pressure check with digital pressure gauge

How to validate: Mechanical Control

- Pressure differential
  - Airflow intensity
  - Pressure translates to velocity
- Filtration
  - Physical removal of particles
  - Proper installation

Why Validate?

- Existing Conditions of Ventilation Systems
  - Area control
    - Comfort and moisture management
    - Fire management
    - Infection control needs for:
      - Airborne spread infectious diseases
      - Surge of unknown infectious patients
        - Infectious disease event
      - Construction aerosol control
      - Potentially infectious
      - Environmental microbes

Managing aerosol presents challenges for construction in hospitals.

Routine cleaning helps maintain cleanliness necessary for safe patient care during construction.

How to validate: Particle Counters

- Filter Management
  - Objective reduction of particles
    - Filtration validation
    - Quality Check
    - Standards modified ISO
      - Before occupancy
      - After occupancy
  - Interpretation
    - Rank order
    - I/O ratio
    - Particle size
    - Construction (ID) Zone vs. clean area
How to Validate: Tools

• Pressure Gauges
  – Airflow management
  • Test location
  • Intensity of airflow
  • Direction consistency
  • Interpretation
  • Velocity and pressure

Removal Efficiency In-Situ by Particle Size and Resistance to Flow

![Particle Counter](image)

Depiction of particle counts before and after filtration in air handling system

Sample log for measuring particle counts

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>Particle Size</th>
<th>Count</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1/2023</td>
<td>10:00 AM</td>
<td>Lobby</td>
<td>0.5 microns</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>1/1/2023</td>
<td>2:00 PM</td>
<td>Office</td>
<td>1 microns</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

Before filter
12176 p/ft^3

After filter
40 p/ft^3

>99% reduction

VENTILATION CHECK LIST
FILTERS

How to Assure Isolation
Ventilation Parameters

• Fixed rooms
  – Local control
    • Dilution ventilation
      – High volume purified air
    • Particle capture
      – Filtered room air
    • Airflow direction
      – Directional for control
  – Portable HEPA Filter Utilization

Determining Air Exchanges

ACH (Air changes per hour):
60 minutes x Airflow (cubic feet/minute)
Room Volume

Airflow = Mechanically exhausted airflow rate in cubic feet per minute (cfm)
Volume = Room air volume = (length x width x height) in cubic feet (ft^3)

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Surge Capacity
- Isolation surge capacity is the ability to manage high volumes of specialized patients.
- Permanent and temporary
  - Smoke zones, engineered system and temp surge

Ante Rooms are not required as a minimum except in certain states.

Knowing a good barrier from a bad depends on pressure management?

Which barriers will help control the airflow direction?

Monitoring Devices
- Flutter strip
- Digital pressure gauge
- Ping pong ball
- Cheap flutter strip

Portable filters
- Isolation with plastic and HEPA are used
  - Patient isolation
    - Short term
    - Construction isolation
    - Short and long term

EID Surge Capacity Criteria
- Airflow in surge area should remain negative, optimally 0.01 inch w.g. (2.5 pa)
- Area should be physically separated from other areas by doors
- Air from this area should not re-circulate to other areas
- Exhaust air outside building > 25 feet from air intakes and public areas
- No flow-through traffic
- Maintain required means of egress
- Capable of function within 12 hours
- Mechanical upgrade and/or improvised

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Smoke Zone
Pressure management for smoke control

Specified areas within the healthcare facility can create an isolation zone if the contaminated air is relieved to the outside. This requires sophistication in the controls that will allow for other priorities to be maintained: fire mgmt, fresh air makeup, etc. But this process can be improvised to expedite the need for ventilation control.

Essential Ventilation Parameters

- Room air exchanges per hour
  - each air exchange reduces particles about 66%
  - All and PE rooms at >12 ac/hr
- Pressure control for All & PE rooms
  - air velocity to create 0.01 inch w.g. (2.5 Pascals)
  - air velocity 0.001"wg=120 lfm, 0.01"wg=400 lfm, 0.1"wg=1300 lfm
  - design for >125 cfm offset for supply versus exhaust
  - minimal leakage < 0.5ft²
- Filtration supply to PE rooms & exhaust from All rooms
  - particle reduction to include both viable and nonviable particles
  - rank order reduction of particles from dirty to cleanest areas
  - non viable particles can be analyzed real time

Contaminated air must be controlled

FILTER VERIFICATION

Training for temporary negative pressure isolation can be found at:
www.health.state.mn.us/oep/training/bhpp/airbornenegative.pdf
Training modules with certification for TNPI found at:
www.meret.umn.edu

Introduction to Sanitation

- Chain/ring of infection control
- Sanitation practice during patient care
- Validation of sanitation
  - Methods
    - Culture
    - Real time visual
    - Surrogate
  - Comparison correlations
    - Contact time with bioload relationship
    - Chemical inactivation indicator

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Provide Sanitation Training for response to infectious events

- Clean up of the environment is needed to control emerging infectious diseases
- Knowledge of good sanitation practice is essential for controlling certain environmental contaminants

Water related incidences
At University of Minnesota Medical Center, Fairview from 11/21/06 to 11/20/07

1364 total water events
71 water events in Bone Marrow Transplant (BMT)

- 612 toilet plugged
- 47 showers plugged
- 41 shower leaking
- 32 sink leaking
- 22 water leaks

- 20 toilet plugged
- 20 sink plugged

Emerging Infectious Diseases
Environmental Associated Infectious Diseases

- MRSA
  - Skin contaminant
- VRE
  - Gastrointestinal organism
- C. DIFFICILE
  - Resistant spores
- NORO VIRUS
  - Low infectious dose

Patient events

- Vomit
  - Captured in basins
  - Environmental contamination
- Fecal material
  - In toilet or UT appliances
  - Environmental contamination
- Blood
  - Blood borne precautions

Introduction to Sanitation

- Definition of terms
  - Sanitize: a reduction of microbial contamination to safe levels as judged by public health standards or requirements.
  - Disinfect: a less lethal process of microbial inactivation (compared to sterilization) that eliminates virtually all recognized pathogenic microorganisms but not necessarily all microbial forms (e.g., spores)
  - Sterilize: the use of a physical or chemical procedure to destroy all microbial life including microbial forms.
  - D-value: time required to reduce microbial population by one-tenth its number or one-logarithm reduction.

Today’s Sanitation issues:

- Consistent daily cleaning
  - Surfaces commonly contaminated
  - Surfaces “off” limits?
- Environmental event driven cleaning
  - Patient substance contamination
  - Plumbing related incidents

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Sanitation Practice comes with Disease Management.

- Review
- Day by day application of learning
- Airborne infection isolation and construction management principles
  - Demonstrate concepts
- Sanitation of surfaces
  - Body fluid and building spills daily decontamination requirements
  - Validation of cleaning

Body Waste Management

- Access to sick patient body substance
  - Health care workers
  - Family members
  - Housekeeping staff
  - Maintenance personnel
  - Nutrition service
- Disposal process
  - Waste into hopper or toilet
  - Disposal of patient cleaning material
- Sanitation
  - Basins for collection
  - Environmental splatter
  - Hands & clothing

How to Validate Sanitation

- Visual
- Culture
- Real Time Analysis

ATP technology a measure of cleanliness?

Did you ever think the Kreb's cycle was important??

Real time environmental survey for cleanliness

ATP surface sampling study

University of Minnesota Medical Center

How to perform ATP Bioluminescent surface testing - Swabbing technique

Hold the swab between the thumb and forefinger, in such a way that the swab can be rotated

Do not touch the swab near the swab bud

Apply downward pressure

Rotate swab during sampling

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How to perform ATP Bioluminescent surface testing - Swabbing pattern

After following manufacturer’s instructions: results take less than a minute
• ATP is the “energy currency molecule” all cells utilize
• Results are in Relative Light Units (RLU)

Audit UMMC-Fairview ATP Patient Care Baseline Levels

<table>
<thead>
<tr>
<th>Surfaces</th>
<th>Mean RLU values</th>
<th>Median RLU values</th>
<th>Range (RLU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrail</td>
<td>247</td>
<td>618</td>
<td>363 - 142</td>
</tr>
<tr>
<td>Keyboard</td>
<td>223</td>
<td>238</td>
<td>111 - 71</td>
</tr>
<tr>
<td>Treatment Cart</td>
<td>399</td>
<td>309</td>
<td>129 - 104</td>
</tr>
<tr>
<td>Door knob</td>
<td>604</td>
<td>445</td>
<td>379 - 282</td>
</tr>
<tr>
<td>Toilet flush knob</td>
<td>422</td>
<td>516</td>
<td>194 - 126</td>
</tr>
</tbody>
</table>

Audit of bedrail cleaning with ATP surface sampling

Why is body Substance Cleaning Inconsistent?
• Standard Precautions?
• Multiple Care givers
  - visitors & healthcare worker
• Multiple persons for cleanup
  - visitor, HCW, housekeeping, maintenance worker

Develop Alert Plan
• Vomit alert
  – Determine 2 step clean up
  – Use appropriate disinfectant
• Brown alert
  – Determine 2 step clean up
  – Use appropriate disinfectant
• Sewer overflow alert
  – Determine 2 step clean up
  – Use appropriate disinfectant

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Body substance issues
• Two step cleanup
  – Remove solid organic
  – Disinfect
• Disinfectant
  – Hospital approved
  – Chlorine and chlorine compounds
  – Steam
  – Gas fumigation
• Where to disinfect
  – Who reports discharge?
  – Who cleans it up?
  – Who disinfects?

Training for Respective Care Givers
• What do hospital employees do for body discharge
  – Not all body discharge is infectious?
• Family and visitor response
  – What do they need to know?
• Housekeeping and maintenance response
  – How do they disinfect after backup?
  – Disinfection after clean out and toilet plug?

Emphasis on Contamination Management
• What did you touch after you touched?
  – Your response is appropriate
  – But your reaction to cleaning will prevent spread….
• Should we do something different for suspect infectious body substance cleanup or make it consistent?

Cleanliness Verification
• Hands
  – Demonstrate compliance of hand washing
• Air quality
  – Demonstrate comparison data
• Surfaces
  – Demonstrate cleaning
• Training
  – Demonstrate understanding and competency

Incident management infectious disease element
• Consistent response to body fluid clean-up
  – Patient care giver & visitor
  – Maintenance & Plumbers
  – Housekeeping
• Proper disposal of wipes and other non water soluble material

Water and Air Sanitation
• Water problems can come at you fast
  – Response plans for cleaning and drying
  – Sanitization of surfaces
  – Mitigation of mold before it grows
• Air quality can deteriorate without knowing
  – Preventative maintenance is essential
  – Planning provides for sustainability for comfort & infection control

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