Hospital Environment

Animate
- Man
  - Patient
  - HCWs
  - Visitors
- Animal
  - Pet
  - Vectors

Inanimate
- Building
  - Air - Temp., %RH
  - Ventilation
  - Water - Sink, Reservoir
- Equipment

Air
- Air-Handling Systems
- Ventilation Requirements for AIIR, PE and OR
- Air cleaning - HEPA filter, UVGI, Air cleaner

Theatre/buildings
- Design, Construction, Renovation, Remediation, Repair, and Demolition

Water
- Controlling the Spread of Waterborne Microorganisms
- Control Strategies for Preventing Legionnaires Disease
- Cooling Towers and Evaporative Condensers
- Dialysis Water Quality and Dialysate

Environmental Services
- Cleaning and Disinfecting Strategies for Environmental Surfaces
- Cleaning Spills of Blood and Body Substances
- Carpeting and Cloth Furnishings
- Flowers and Plants
- Pest Control
Hospital Environment

- Environmental Sampling
  - Air, Water, and Environmental Surface Sampling
- Laundry and Bedding
  - Laundry Facilities and Equipment
  - Routine Handling of Contaminated Laundry
  - Laundry Process
  - Microbiologic Sampling of Textiles

Regulated Medical Wastes
- Disposal Plan
- Handling, Transporting, and Storing
- Treatment and Disposal

Animals in Health-Care Facilities
- Protective Measures for Immunocompromised Patients
- Research Animals

Contents

- Air - Ventilation, UVGI, Air cleaner
- Environmental Services - Cleaning and Disinfecting Environmental Surfaces
- Environmental Sampling - Air and Surface Sampling
- Theatre/buildings
- Water
- Waste
- Linen/laundry

Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Facilities, 2005

Administrative controls/Work practice
- Engineering/Environmental controls
- Personal controls

Administrative Control
Environment Control
Personal Control

Administrative Controls

- Assessment of the risk
- Development of IC plan
- Adequate training of HCWs
- Patient education
- Sputum collection
- Encourage out-patient TB management
- Triage and evaluation of suspect TB patient for early diagnosis and treatment

Risk levels for HCWs: Physical areas

<table>
<thead>
<tr>
<th>Locations at Health Facilities</th>
<th>Low Risk</th>
<th>Medium Risk</th>
<th>High Risk</th>
<th>Very High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration Deans such as hospital or support centers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Administrative officers (e.g., hospital directors)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Administration of areas with direct patient or support contacts or air ventilation from patients</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maternity and Paediatrics Ward</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MNCA and high-risk patients</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Outpatients Department</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Intensive Care and Intensive Medicine Ward</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TB Isolation rooms</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TB Isolation wards</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>
| Reference: IMPLEMENTING the WHO Policy on TB Infection Control, 2010

Risk levels for HCWs: Functional areas

- Procedure at health facilities
- Biology laboratories
- Surgery
- X-ray services
- Respiratory Therapy such as spirometry
- Isolation
- Biohazardous services
- Culture and Gram staining of sputum specimens
- Molecular testing with low throughput specimen processing
- Sputum collection
- Specimen induction

Personal control, PPE/RPE

- 3rd priority, least effective
- Aim to protect HCWs from inhaling infectious droplets
- Without appropriate administrative and environmental controls
Recognize and strict implementation of the standard manual for the prevention - **Work practice**

Personal Hygiene - **Hand wash**

Personal Protective Equipment, PPE

**Environmental Controls**

**Personal control, PPE/RPE**

- Recognition and strict implementation of the standard manual for the prevention
- **Work practice**
- Personal Hygiene - **Hand wash**
- Personal Protective Equipment, PPE

**Environmental Control**

- **2nd priority: Reduce** droplet nuclei in the air
- Control source of infection - Local exhausted ventilation
- **Ventilation**
  - Proper airflow direction - Clean to less-clean air
  - Adequate airflow - Dilution and removal - ACH
  - General ventilation - Natural & Mechanical ventilation
- **Air cleaning**
  - Filtration - High-Efficiency Particulate Air (HEPA)
  - Ultra-Violet Germicidal Irradiation (UVGI)

**Local Exhaust Ventilation (1)**

- **Source control** method for capturing airborne contaminants
- Should remove at least 99% of particles before next patient or HCW enters

**Local Exhaust Ventilation (2)**

- **Enclosing device**: source fully or partially enclosed
  - Tents
  - Booths
  - Biological safety cabinets (BSCs)

- **External device**: source near but outside enclosure
**Direction Airflow**

- Clean to less clean
- Positive-Negative pressure room

**Ventilation systems**

- **Natural ventilation** through open windows (simplest, least expensive).
- **Mechanical ventilation** eg. window fans, exhaust ventilation, closed recirculation filtration system.

**Ventilation systems**

- **Dilute** contaminated air
- **Remove** contaminated air
- **Control directional airflow** patterns in a room

**Air Filter**

<table>
<thead>
<tr>
<th>Filter Efficiency</th>
<th>Pre-Filter</th>
<th>Medium Filter</th>
<th>HEPA Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtration Efficiency</td>
<td>90%</td>
<td>95%</td>
<td>99.97%</td>
</tr>
</tbody>
</table>
High Efficiency Particulate Air Filter

“HEPA”

- Remove at least \[99.97\%\] of airborne particles
  - \[0.3 \, \mu m\]

HEPA Filter

- Use as supplement to ventilation system
- Used to removal of infectious airborne and droplet nuclei from the air

Isolation Room

- Airborne Infection Isolation Room (AIIR)
- Protective Environment Room (PE)

Design standards
- Operational system
- Monitor and maintenance

Airborne Infectious Disease

<table>
<thead>
<tr>
<th>Ventilation parameters</th>
<th>Airborne infection</th>
<th>Protective environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air changes per hour</td>
<td>More than 12</td>
<td>More than 12</td>
</tr>
<tr>
<td>Filtration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Supply</td>
<td>90% dust spot</td>
<td>60.9% at 0.3 , \mu m</td>
</tr>
<tr>
<td>- Return</td>
<td>99.97% at 0.3 , \mu m</td>
<td></td>
</tr>
<tr>
<td>- Toilet</td>
<td>100% exhaust</td>
<td>100% exhaust</td>
</tr>
<tr>
<td>Supply versus exhaust offset</td>
<td>More than 126 cfm</td>
<td>More than 126 cfm</td>
</tr>
<tr>
<td>Air-flow direction</td>
<td>Into room</td>
<td>Out of room</td>
</tr>
<tr>
<td>Pressure differential</td>
<td>Over 0.01 in.H2O</td>
<td>Over 0.01 in.H2O</td>
</tr>
<tr>
<td>Minimum room leakage</td>
<td>Less than 0.5 sq. ft</td>
<td>Less than 0.5 sq. ft</td>
</tr>
</tbody>
</table>
F. Recommendations—Environmental Sampling

I. General Information
   A. Do not conduct routine, reduced microbiologic sampling of air, water, and environmental surfaces in healthcare facilities. Category IB
   B. When indicated, conduct microbiologic sampling as part of an epidemiologic investigation or during assessment of unusual environmental conditions to define contamination and identify sources of infection. Category IB
   C. Limit microbiologic sampling for quality assurance purposes to i) biological monitoring of disinfection processes; ii) monthly cultures of water and drainage in hemodialysis units; and iii) surveillance monitoring of the impact of infection-control interventions or changes in infection-control practices. Category IB

II. Air, Water, and Environmental Surface Sampling
   A. When conducting any form of environmental sampling, identify existing cooperative standards and fully document departures from standard methods. Category IB
   B. Select a high-volume air sampling device if sampled levels of microorganisms are expected to be low. Category IB
   C. Do not use settle plates to quantify the concentration of airborne fungal spores. Category IB
**Thoroughness of Environmental Cleaning**

![Graph showing cleaning efficiency](graph.png)

Source: PC Carling et al., SHEA 2010

**High touch areas in patient rooms are not cleaned consistently – Carling study (2008)**

![Image showing cleaning efficiency](image.png)

Source: PC Carling et al., SHEA 2007 and ICHE 2008; 29:1

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**RODAC plates**

![RODAC plates](rodac.png)

**Phase I: Examine baseline conventional cleaning evaluation**

- 5 days
- 330 samplings

![Phase I diagram](phase_i.png)

**Phase II: Examine the efficiency of H2O2**

- 11 days
- 1,089 samplings

![Phase II diagram](phase_ii.png)
Room Cleaning: Result

<table>
<thead>
<tr>
<th>Door1</th>
<th>Door2</th>
<th>Bench</th>
<th>Shelf door</th>
<th>Shelf</th>
<th>Wall1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
</tbody>
</table>

Room Cleaning: Result

<table>
<thead>
<tr>
<th>Floor beside Bed1</th>
<th>Floor beside Bed2</th>
<th>Floor under bench</th>
<th>Floor corner 1</th>
<th>Floor corner 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
<td>Before</td>
</tr>
</tbody>
</table>

“NO-TOUCH”
Decontamination Technologies

- Hydrogen peroxide
  - aHP, H₂O₂ vapour
- UV light (UV-C)
- Chlorine dioxide
- Formaldehyde
- Ozone

Conventional cleaning versus HPV

<table>
<thead>
<tr>
<th>Overall MRSA results</th>
<th>Effect of cleaning</th>
<th>Effect of Bio-Decontamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>74%</td>
<td>Cleaning ineffective: Poor level of reduction</td>
<td></td>
</tr>
<tr>
<td>90%</td>
<td>66%</td>
<td>73%</td>
</tr>
<tr>
<td>60%</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

Percentage of MRSA swabs positive

<table>
<thead>
<tr>
<th>Overall</th>
<th>Before cleaning</th>
<th>After cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room</td>
<td>Room</td>
<td>Room</td>
</tr>
<tr>
<td>Before</td>
<td>After</td>
<td>Before</td>
</tr>
</tbody>
</table>


Infection Control Technology

“UVGI”
Ultraviolet irradiation

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength (nm)</th>
<th>Type and classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVA</td>
<td>320–400</td>
<td>Non-germicidal (Near-UV, Blacklight)</td>
</tr>
<tr>
<td>UVB</td>
<td>280–320</td>
<td>Erythemal</td>
</tr>
<tr>
<td>UV-C</td>
<td>250–280</td>
<td>Ozone-producing</td>
</tr>
<tr>
<td>UV-X</td>
<td>100–210</td>
<td>Vacuum ultraviolet</td>
</tr>
</tbody>
</table>

UV-C Radiation used for disinfection is most effective at a wavelength of 254 nm.

Consideration

- Effectiveness
- Safety
- Appropriated installation
- Maintenance

UVGI

- Requires maintenance, esp. cleaning bulbs
- Not effective at high humidity (>70%)
- Occupational exposure limits: eye & skin
- Upper air UVGI devices must be properly designed, installed, maintained and operated

Upper room UVGI

- There is a high ceiling (so people cannot look into the lamp) ceiling > 9 feet or ~ 3 m.
- Fans or ventilation system mix the disinfected upper room air with the potentially contaminated air below
UVGI maintenance
- Monitoring radiation levels
- Cleaning (turn off before cleaning)
- Replacing bulbs as recommended by manufacturer (~ 9,000 hr.)
- Keeping records of monitoring and maintenance activities

UVGI summary
- There are evidences that UVGI can reduce transmission of *M. tuberculosis* in health care settings.
- Upper air UVGI is recommended in areas that is large space without adequate ventilation and highly contaminated with infectious microorganisms.
- Adequate air circulating to expose UV in upper air irradiation is necessary for effectiveness

Portable Air Cleaner
- **Active removal pollutions**
  - Plasma cluster
  - Ozone
  - Photo catalytic reactor
- **Passive removal pollutions**
  - HEPA filter
  - Negative ion
  - UVGI
**Portable air cleaner**

- **HEPA** - Not kill, only trap particles
- **Negative ion** - Not kill, refresh air only
- **Ozone** - Not trap, kill
- **UVGI** - Not trap, kill
- **Plasma cluster** - Not trap, kill

Engineering control summary (1)

- 1st priority is Administrative controls, but Engineering controls are complementary
- Dilution ventilation, UVGI, and HEPA filter units are all effective under ideal laboratory conditions
- Best data in field support dilution ventilation
- Dilution ventilation is most important for all
  - Can add to comfort
  - But limited by technology, expense

Source: Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Facilities, 2005.

**Engineering control summary (2)**

- Advantage of ventilation is usually “Always on” minimizing human errors.
- Disadvantages of UVGI and HEPA
  - Maintenance (increased human errors)
  - Large variability of effectiveness
- UVGI and filtration devices are adjuncts for high risk areas
  - Back-up when not possible to ventilate well
Infection Control & Safety:
Everyone Is Responsible!

SAWASDEE KRUB...!!!

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