Laundry Facilities:
Helping to Prevent Microbial Contamination and Healthcare-Acquired Infection

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• 40 years service at U of Minnesota infection prevention.
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Coordinated CDC’s 2003 healthcare environmental infection control guideline

Specializes in microbial inactivation and environmental infection control
Today's Topics

- Why is our topic important for today's laundry industry?
  - The goal is improved quality control for your facility's product: hygienically clean healthcare textiles (HCT)
  - "Textile-mediated transmission (TMT)"
  - Root cause analysis of outbreaks: what went wrong
  - Environmental pathogens
- Laundry facility cleanliness
  - Look for sources of dust and lint accumulation
  - Assessment methods: pros and cons
- Possible infection prevention actions for known problems

Preventive Action is Needed Now, and Here's Why

- Environmental pathogens are "opportunistic pathogens" - a problem for high-risk patients
- Hospitals provide care to increasing percentages of high-risk patients
- Emergence of high-mortality infectious pathogens
  - Fungi - Aspergillus spp, Mucorales
  - Limited anti-fungal treatments
- Epidemiologic investigations
- Laundry facility HACCP reviews/problem solving

Patient Levels of Risk

Healthy person
- Chronic obstructive pulmonary disease
- Diabetes
- Extensive burns
- Premature babies
- Steroids
- Cancer - solid tumor
- HIV infection - end stage of spectrum
- Organ transplant
  - Kidney/heart
  - Lung/liver
- Malignancy - leukemia/lymphoma
- Bone marrow transplant (BMT) allograft

Chain of Infection

Low

High
What is Mucormycosis?

- Rare, life-threatening fungal infection
- Fungi belonging to the family Mucoraceae (e.g., Rhizopus spp.)
- Patients at risk:
  - Immunocompromised patients
  - Hyperglycemic patients, acidosis patients
  - Patients with elevated serum iron levels
- Prevalence among HSCT patients: 2% – 3%; in the US population: 1.7 cases/million population
- Angioinvasion with resultant vessel thrombosis and tissue necrosis


Photo source: CDC Public Health Image Library

Five Major Clinical Forms of Mucormycosis

- Rhinocerebral
  - Commonly seen in HSCT patients, neutropenic cancer patients, and patients with diabetic ketoacidosis
- Pulmonary (lung)
  - Blood cancer patients, severe neutropenic patients, steroid therapy patients
- Gastrointestinal
  - Malnourished patients, transplant patients
- Cutaneous (skin)
  - Burn patients, patients with trauma to the skin
- Disseminated
  - Neutropenic patients with a pulmonary infection

CDC: Clinical Features of Mucormycosis www.cdc.gov/fungal/diseases/mucormycosis/symptoms/clinical-features.html
Published Outbreaks Attributed to Laundered HCTs

• 14 outbreaks in 44 years worldwide attributed to laundered, clean HCTs
  - U.K. – 4, U.S. – 4, Japan – 3, Singapore – 1, Netherlands – 1, Hong Kong – 1
  - > 356 patients affected
  - Pathogens identified:
    - Acinetobacter spp.
    - Aspergillus flavus
    - Bacillus cereus (7/14, 50.0% of the outbreaks)
    - Streptococcus pyogenes
    - Mucorales (Rhizopus delemar, Rhizopus microsporus, Lichtheimia spp., Rhizopus oryzae) (3/14, 21.4% of the outbreaks)
    - Clostridioides difficile

Outbreaks Associated with Laundered HCTs: Frequently Reported Root Causes

Four Key Observations: Infections and HCTs

• Outbreaks involve environmental contamination and failure to maintain HCT cleanliness after washing and drying
• Root causes identified and corrected
• Problems with laundry equipment and storage are most frequently identified
• Equipment problems lead to contamination in the wash
• Patient-to-patient transmission of infection has not as yet been reported in association with hygienically-clean HCTs
• In-use HCTs could serve as carriers of pathogens
• Rare events, but underreporting is assumed
Does Mold Grow on Laundry?

- On lint, yes and yes, on laundry
- Moisture conditions must be satisfied

Does Laundry get Contaminated After Washing?

- It depends on what is meant by “contaminated:”
  - A spore or two - yes, certainly
  - Depends on growth conditions?
  - Water, food, time, and temperature
  - Mold spores germinate quickly and grow quickly
Biodegradation of Textiles

- Textiles, especially those containing natural fibers, are readily attacked by microbes
  - Some processing and finishing agents (e.g., dyes) are also vulnerable
  - Over time: loss of strength, discoloration, change of appearance, odor
- Fungi are the most important microbial class associated with biodegradation
- Three things necessary for fungal growth:
  - Food source (e.g., cellulose)
  - Moisture
  - Favorable environmental conditions (e.g., temperature, humidity)

Primary Sources and Reservoirs of Fungi in the Laundry Environment

- Lint and dust accumulation on surfaces
- Air - fungal spores can be airborne indefinitely
- Intrusion of outside air that may contaminate laundry and dryer equipment
- Fungal contamination of HCTs may occur at any point in the laundry process from wash all the way to storage in the hospital's storage area
- Manage/prevent the environmental conditions that favor fungal growth

Cotton clothes found to be leading carrier of fungal spores, a scourge to some hospital patients with damaged immune systems

Kay Odenstor & Betty Dart, Cornell Univ.

The researchers also found that laundering is highly effective in removing the spores. Thus, simply having staff and visitors cover their clothing with hospital-laundered garments and shoe covers before entering patients' rooms would significantly reduce the risk of infection. Such policies, Odenstor says, are currently not pervasive, standardized or enforced.

Dust sources

Particles cling to clothing

Aerosols can be generated inside or outside. These particle aerosols float with the air currents.

Control measures for particle source

Accumulated dust in/on the fan housing was full of the fungus Aspergillus fumigatus spores recovered with surface contact plates. Six patients had skin infections.

Fan Cleanliness and Maintenance is Important

Fan Cleanliness and Maintenance is Important

Sources:
- Air intake step-down residence
- Mold cancer clinic pharmacy
- Oncology clinic linen storage
- Behind the wall board

Fungal Hiding Places
Water damage is relatively common in the janitor’s closet.

Water resistant materials will prove to be value added to construction and renovation.

Inspections should evaluate these water damage issues.

Lint accumulates on the roof depending on roof design.

Mold will grow on the lint when it gets wet.

Then when it dries it flies.

Lint is an Ideal Growth Media for Various Microbes Including Fungi

Discharge lint around exhausts

Drifts of lint

Air intakes for dryers
Look for Lint in the Rafters?

Certainly accumulation of lint can be a problem for microbial growth and fire.

Does blow-down help control microbial growth in lint?

What Does the Fire Code Have to Do with Infection Control?

It's a Two for the Price of One!
Laundry Fire Prevention Planning and Dryers

Facility laundry fires are one of the more common incidences reported. Most of these are associated with the dryer. Commercial dryers have all the ingredients: heat, fuel, and air. This notice is a reminder of safe laundry operations.

Whenever dryers are in use, the laundry must be staffed, and staff shall be knowledgeable of who is using the dryer and what its contents are. A clothes dryer should never be left unattended while operating.

Dryer Maintenance

- Preventative maintenance should be provided to all dryers:
  - Do not allow lint to build up in the dryer case, exhaust pipes or traps.
  - Inspect and clean all lint after each day's use of the dryers.
  - Verify daily that air is exhausted through the exhaust prior to using the dryers.
  - Lint accumulating on sprinkler heads, heat detectors, or anywhere outside the dryer system is a problem that needs to be checked by a mechanical contractor.
  - Lint should not accumulate on the building exterior (roof, walls, or ground).

Pressure management is difficult with dryer demand during operation. Clean to dirty airflow should be a requirement. How do you control plant air pressure when the dryers are turned on?
Mold Growth Management

- Mold growth
  - ~4 hours with ideal conditions
- Mycelial growth
- Sporulation about 72 to 96 hours
- Dissemination of spores
- Mold Growth Conditions
  - ~25% water content
  - Approximately 95% relative humidity
- Interrupt growth
  - Reduce moisture
  - Resistant substrate

Simplified Psychometric Chart

Moisture indicating instruments are useful for quantifying water content in laundry.

When the surface has 25% moisture and the RH is 95%, spores germinate and grow into new spores within 96 hours of ideal conditions.
Mucormycosis in a Hong Kong Hospital Associated with Contaminated HCTs – 2015

- Laundry A inspection/assessment:
  - Workload increased 25% between 2011 and 2015; 14.43 million items laundered
- Laundry A facility environment:
  - Indoor temperature: 81°F, relative humidity: 79%, dew point: 80°F
  - Thick layer of dust on fans, equipment surfaces, and duct outlets
  - 61% (119/195) environmental samples positive for zygomycetes
- Infrared temperature readings of washing equipment did not match preset temperature settings (140°F vs. 160°F)
- Linens felt warm and moist to touch in packing area


Climate Control via Ventilation:
Key Hospital Engineering Specifications

- Why this is important:
  - Fungi grow rapidly at >85% RH
- Keeping the ventilation parameters consistent helps to minimize fungal growth
- Trapped excess moisture due to condensation for weeks can create moisture conducive to fungal growth
- Not some portions of high humidity, but the whole HCT bundle
- Also may occur in wash water basin if room remains humid
- Higher temperatures encourage fungal growth

Clean HCT Storage:
- Temperature: 72 – 78°F
- Relative humidity: 50% – 60%
- Air changes/hour (ACH): 2
- Airflow direction: Positive

Surgical Pack Room Storage:
- Temperature: <78°F
- Relative humidity: <70%
- Air changes/hour (ACH): 2
- Airflow direction: Positive

Hold/Staging at the Laundry:
- Contamination exposure of clean textiles

Innovation of methods to prevent inapparent contamination of laundry product needs investigation and incorporation into the manufacturing process.

Breaking the Chain of Infection
Potential Sources of Contamination in Storage Areas

Humidity management out of control allows for condensation on the vane diffuser because of aspirating humid air and contact with cold air. Condensation occurs.

Inadequate barriers in the areas where clean laundry is stored can also allow for contamination of clean to dirty airflow if not maintained.

Which One of These Could be a Problem?

Air quality in the sorting area

Are liners a waste of time?

Storage outside?

What if this ceiling problem is above clean laundry?

Laundry Holding/Transport/Storage

- Controlling the environmental conditions is considered to be the best means of protecting textiles
- Clean HCTs touch clean surfaces
  - That includes clean hands and worker uniforms
- HCTs should be as dry as practical prior to bundling or packaging
- Unwrapped HCTs should be stored and transported using strategies to prevent inadvertent contamination by soil or body substances
  - Covered containment, either bins, carts, or shelves
Transportation Issues for Considerations

Cleanliness of transport containers must be considered. Cleanability of the surfaces is needed. Warm humid conditions can promote mold growth. Water condensation can occur when warm laundry is brought outside to the truck during cold weather. Air holds 50% more water vapor with each 23° F rise in temperature. Likewise, the humidity comes out of air as it cools.

Laundry Holding/Transport/Storage:

Area Cleanliness and Dust Control in Hospital Storage Areas

- Evaluate HCT storage area in the hospital for ways to minimize dust intrusion
- Self-closing doors help to maintain positive pressurization
- Location of HCT storage room relative to the loading dock and other services
- Amount of traffic through the room
- Establish hospital policy for regular cleaning and disinfection of the room's storage surfaces
- Where are clean HCTs unloaded in the hospital?
- Visual inspection of outermost bundle surfaces

Tools for Environmental Assessment:

Indications for Use, Pros & Cons
Real-Time Measurements of Physical Parameters

- Real-time measurements give you instant information
- Examples:
  - Inspection/observation of the facility: HACCP
  - Physical parameters: temperature, relative humidity, cleanliness
  - Airflow direction for functional separation of clean areas and soiled areas
  - Pressure relationships
  - Particle counts (typically used for air quality measurements)
- Pros: easy to do, just-in-time repairs and confirmation of repair success
- Cons: Not specific for fungi or any other microbes

Microbial Sampling of Surfaces

- Can be used to identify specific microorganisms and/or just determine the density of microbial colonies per a unit area
- Methods: air sampling, water sampling, surface sampling with contact plates (RODAC) or tape sampling
- Pros: reveals identify and numbers of microbes
- Cons: results may not reflect current conditions of surfaces; not a "real-time" test method

Air sampling with a cone on a sieve impactor allows for vacuuming the surface of the cloth to extract viable particles.

This method will help determine what is on the laundry as well as what is on the floor.
Issues with Microbial Testing of HCTs

- Current methods used are not real-time testing
- Testing of HCTs prior to bundling doesn’t pinpoint the process problem leading to contamination
- HCTs may not have bioburden evenly distributed over the entire surface of the textile
- Collection of the sample in the laundry doesn’t account for potential increased bioburden during transport and hospital storage
- Potential liability issue for a “fail” HCT load that’s been shipped to the hospital before results were known
To Sum It All Up:

Known Problems and Possible Corrective Measures

Cleanliness

- Facility:
  - Observation: note dust and lint accumulations
  - Regular schedule of blow-down
  - Regular schedule of surface cleaning to remove dust, lint
- HCTs:
  - All surfaces in contact with laundered HCTs should be clean
  - Establish in-facility benchmark for ATPase testing of surfaces
  - Ensure clean HCTs are covered to minimize environmental contamination during transport
  - Consider sterilization for HCTs to be used for high-risk patients (may be done at the hospital)

Prevent Intrusion of Dust and Lint from the Outdoors

- Inspect the facility’s roof for accumulation of lint around air exhaust vents
- Note location relative to air intake for dryers and other equipment; be aware of prevailing wind patterns
- Installation of in-line filters in the air intakes should be considered to prevent post-laundering contamination of HCTs with particulates from the outside
Humidity Control for Bundled HCTs

• Dry the HCTs as thoroughly as possible prior to bundling
• Note that flat ironers do not produce fully dry sheets or other ironed items

Why is this important?
• During their stay in the hospital, patients will have the greatest degree of contact with sheets, pillowcases, etc. compared to any other surface in the hospital
• Moisture conditions will change as patients lay on HCTs, gowns

• Control the ambient temperature of the bundles
• Relative humidity in the bundles changes with temperature changes

Is Humidity Control Practical in a Laundry Facility?

Goal:
• Control condensation in the facility
  • Temperature changes lead to condensation on surfaces
  • Promotes growth of fungi on surfaces, especially on dusty surfaces
• Keep the condensation chart handy for reference
• Know what the relative humidity levels are in the various areas within your facility

What other Best Practice measures could be used for humidity management?

Percentages of HCTs Positive for Fungi: Culture Results by Hospital

10% was the culture-positive benchmark used to define HCTs as hygienically clean. Any pathogenic fungi included Fusarium and other dematiaceous molds.
Observations from the Study

- Hospitals surveyed were transplant and cancer hospitals.
- RODAC testing of HCTs upon delivery at the hospitals
- 33% (5/15) HCTs soiled, 20% (3/15) carts soiled
- Mucorales contamination on HCTs from 47% (7/15) hospitals
- "Visibly-soiled HCTs or carts and higher maximum temperatures and relative humidities in the vicinity of a laundry were significantly associated with Mucorales-contaminated HCTs."
- Environmental remediation at the laundry – cart cleaning, lint control activities
- Details?

Infection Prevention Questions Raised

- Should the hospital accept laundry as is or should they consider sterilizing HCTs?
  - Surgery and aseptic procedures
  - Special susceptible patients
- Laundry production standards for infection prevention?
  - Clean linen handling processes after washing
  - Contamination control
    - outside air?
    - moisture management
  - clean laundry protection
  - storage areas
Thank You!

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