Hazard Vulnerability Analysis for Infection Control

Andrew Streifel, University of Minnesota

A Webber Training Teleclass

Hazard Vulnerability Analysis Infection Control

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Hosted by Paul Webber paul@webbertraining.com

Planning for a disaster with the idea it will never happen didn't know Murphy's Law?

What to Check per Disaster

- Earthquake
  - Infrastructure damage & water damage
  - Mechanical system dysfunction
  - Water damage
- Flood
  - Water damage
  - Mechanical and Electrical dysfunction
- Fire
  - Infrastructure damage
  - Water damage
- Hurricane/tornado
  - Infrastructure damage
  - Water damage

Hazard Analysis of Critical Control Points-1

HOSPITAL CONSTRUCTION

- Understand process steps
  - Administrative controls
    - Policy, procedures training
      Commitment to safety
  - Engineering Controls
    - Ventilation management
    - Cleanliness
  - Personal protection
    - Hazard analysis
    - Training

Risk Assessment- Administrative Issues

- Life Safety Codes
- Emergency management plan; Emergency operations plan
- JCAHO; CMS; State and local AHJs enforcement

Background - Codes & Guidelines

- Life Safety Codes (LSC)
  - NFPA 99 Ch 12 Framework for emergency operations plan (EOP)
  - NFPA 1600 Std on Disaster/Emergency Management & Business Continuity Programs
- CMS and local AHJ or "Authority Having Jurisdiction"

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Background - Codes & Guidelines

- JCAHO- Environment of Care Chapter
- Enforces LSC
- EC.1.0-8.0- Emergency Management Plan
  - Electrical, Fire Management, Plumbing, Medical Gases
- EC.7.0 – Utilities Management Plan- Ventilation; Plumbing
- Infection control input

Administrative Issues

- Assessment of risks & level of preparedness
- Assessment to determine effects on facility
- General preparation for emergencies
- How to determine vulnerabilities
- Available resources

Administrative Issues Terms

- Mitigation and Remediation
- Disaster - natural or man-made event that significantly disrupts the environment;
- "Potential injury creating events"
- Need to assess current plans for different types of emergencies; evacuation & disaster recovery

Emergency Management Framework

- Assessment – Hazard vulnerability analysis (HVA)
- Mitigation – Use assessments to reveal ways to mitigate effects of a disaster
- Prepare – Some disasters can't be mitigated.. prepare via mutual aid agreements- build capability
- Respond – Action guidelines for staff during disaster
- Recover - Start with actions taken immediately after patients out of danger—to return to pre-disaster conditions

Our Disaster Recovery Plan…

Emergency Management

- How organization establishes and maintains a program; emergency plan
  - Processes for HVA,
  - Incident command system; interaction with community agencies,
  - Staffing, communication, training

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Emergency Management HVA

- Where to start-- Current team
- Locate/review current plan
- Identify staff responsible for functions:
  - Safety, Security, Plant operations
  - Medical staff or MD director, Risk mgmt
  - Infection control, Patient care staff,
  - Communications, Public relations
  - Support areas as applicable

Hazard Vulnerability Analysis

- Tool to identify hazards and the direct/indirect effect they may have on your workplace.
- Provide evidence demonstrating you have gone through the process.
- Excellent start to reviewing/revising plan for readiness, whether or not required

Hazard Vulnerability Analysis

- Develop a simple matrix to assess each event for:
- **Probability** of occurrence
- **Risk** severity or magnitude of impact
- **Preparedness** of your facility

Hazard Vulnerability Analysis
Step 1: List

Refer to Matrix: Left-hand column

- Natural events - Fire, tornado
- Technological events - utility failures such as power outage
- Human-related events - mass casualties, infant abduction

Hazard Vulnerability Analysis

EVENT	PROBABILITY				RISK					PREPAREDNESS			TOTAL
	HIGH	MED	LOW	NONE	LIFE Threat	Health Safety	HIGH Disruption	MOD Disruption	LOW Disruption	POOR	FAIR	GOOD	
SCORE	3	2	1	0	5	4	3	2	1	3	2	1	
NATURAL Events													
Hurricane Tornado													
Severe Thunderstorm Flood external													
Blizzard Ice storm													
Tidal wave Drought													
Wild fire Landslide													
Earthquake Volcano													
Epidemic													

Hazard Vulnerability Analysis

Issues to consider for **probability** include, but are not limited to:

- Known risk
- Historical data
- Manufacturer/vendor statistics

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Smoke, Fire & Weather



Hazard Vulnerability Analysis

Issues to consider for **risk** include, but not limited to:

- Threat to life and/or health
- Disruption of services
- Damage/failure possibilities
- Loss of community trust
- Financial impact
- Legal issues

Hazard Vulnerability Analysis

Issues to consider for **preparedness** include, but are not limited to:

- Status of current plans
- Training status
- Insurance
- Availability of back-up systems
- Community resources

Common Denominator….

- Water…
- Mitigation focus on water

Practical Issues for HVA

- Assessment on historical data
  - Fire drills or real emergencies – how did you evacuate? Did it work well?
  - Bomb threat? Did your past processes work well? Even if not written down, get on paper now.
  - Influenza surge—more capacity needed?
- Walk around
  - Alarms - Do you have different ones?
  - Fire extinguishers, exit signs, emergency lighting—do they work?

Practical Issues for HVA

- Train management first- suggestions
  - Make evacuation map and designated exits, pull alarms, plan on cards for quick overview
  - Tape recording of what all alarm signals are for fire, tornado, medical emergency-
- Train staff
  - Use their involvement eg, to check specific areas & report (eg, bathrooms, public areas)
  - Specific training for employees with responsibilities for turning off electrical service

Practical Issues for HVA

- Biological emergencies and planning
  - Assessment and communication if suspecting unusual symptoms in a patient (s)
  - Communicable disease plan should interface with Emergency Preparedness plan
  - If clinic (no ER) have posters;
  - Communication plan developed;
  - Identify local Infectious Disease or public health resources available to you

Practical Issues for HVA

- Physical Plant issues – ventilation
  - Limited access?; Total lockdown possible?
  - Know type of system (100% vs recirculated air;)
- Capacity in case of influx?
  - Pick a number & plan
- Pharmaceuticals and equipment (NPS); Medical treatment possible? Or plan for transfer
- Staff protective equipment
- Support for crisis counseling?

Part II Mitigation

Critical approach in planning mitigation/ concerns for

- Structural,
- Water
- Mechanical systems

Establish Baseline Knowledge

- Conduct a walk-through inspection of the building and its systems, including
  - Mechanical systems
  - Fire protection- Life-safety systems
  - Water systems
- Compare operation of current systems to "as-built" drawings

Step #1—Know Your Building

- Short-term goals of identifying mitigation you can take immediately
- Concern – airflow patterns and dynamics
- Understand systems:
  - How were they intended to operate?
  - How do they currently operate?
  - Current set of diagrams & operation manuals

Organize Prior to Walkthrough

- Where are key functions located?
- How are mechanical systems controlled?
  - How quickly can it respond?
- How is the building zoned?
  - Where are the air handlers for each zone?
  - Is the system designed for smoke control?

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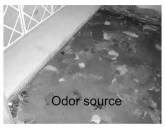
Structural Measures

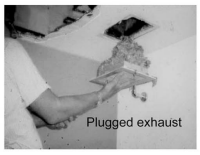
- General Building Physical Security Upgrades
  - Security fencing and control access points
  - Locate doors & utility tunnel access
- Is the building prone to flooding, other?
- The building is urban, suburb or rural?
  - Traffic access
  - Pedestrian access

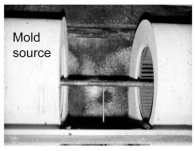
Hospital Water Systems

- Municipal drinking water
- Kidney dialysis
- Laboratory water
- Swimming pool
- Water features
- Emergency supply (well)

Ventilation Deficiencies

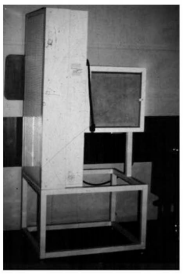






Portable HEPA Filters

- Utility
  - Enhanced ventilation
    - Increase air exchanges
    - Particle reduction
  - Realities
    - Continuous usage
    - Storage
    - Maintenance
    - Utility cost
  - Contingencies
    - Enhance current building systems



Portable filter criteria
•air delivery
•volume output
•noise
•HEPA

Portable HEPA filter
•99.97% efficient for 0.03μm
•directed airflow
•high volume air delivery
•flexible response capability

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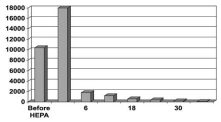
Portable Filters are used to enhance Ventilation.

- remove problem particles
- dependant on size of room and volume output of device
- equivalent air exchanges
- no fresh air



Portable Filters

Advantages	Disadvantages
•Particle reduction	•Cost
•Safety enhancement	•Maintenance
	•Noise & heat

Mechanical Systems

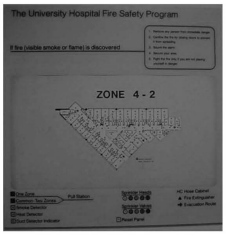
- Planning for Surge capacity– how mitigate demand for negative pressure zones or areas?
- Test that planned systems work
  - Example: Minnesota Manual Methods for Temporary Negative Pressure Isolation
  - http://www.health.state.mn.us/oep/training/bhpp/airbornenegative.pdf

Surge Capacity Criteria

- Airflow in surge area should remain negative, optimally 0.01inch 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

Smoke Zone

Pressure management for smoke control



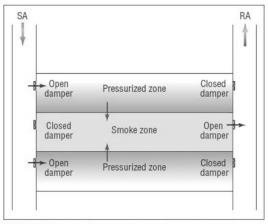


FIGURE 4. Floor-isolation and smoke dampers at shaft penetrations in sandwich-pressurization systems can be used for both smoke control and CBR isolation.

Complex building system control

Contaminated air must be removed from the building

Specified areas within the healthcare facility can create a 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

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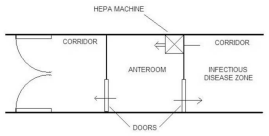

Area with ventilation control an be easily created to manage surge capacity. This is contigent on portable HEPA machine air delivery adaptation to assure negative pressure with filtration to also increase air exchanges.

Mechanical Systems

- Mechanical system
- How does the HVAC system respond to
  - Manual fire alarm,
  - Fire detection, or
  - Fire-suppression device activation?

Training & Maintenance

- Maintenance Staff Training
  - Worker health and safety
  - Drills and simulations
  - Current, accurate system diagrams and labels
- Routine testing and maintenance ensure protection & mitigation systems operate as intended
  - to design specifications

Walkthrough Checklist

- Where are the outdoor air louvers?
- Do adjacent structures or landscaping allow access to the building roof ?
- What is the mechanical condition of the equipment?

Walkthrough Checklist

- What filtration systems are in place?
- Is all equipment appropriately connected and controlled?
- Are all dampers (outdoor air, return air, bypass, fire and smoke) functioning?

Walkthrough Checklist

- Are all supply and return ducts completely connected to their grilles and registers?
- Are the variable air volume (VAV) boxes functioning?
- Are utility chases and penetrations, elevator shafts, and fire stairs significant airflow pathways?
- Is there obvious air infiltration? Is it localized?

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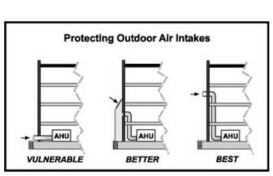
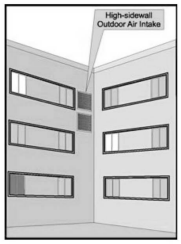
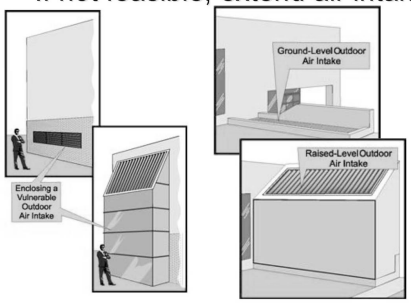
Prevent Access to Outdoor Air Intakes





- Relocate outdoor air intake vent to publicly inaccessible location

If not feasible, extend air intake



VULNERABLE AIR INTAKE

Odor sources create anxiety to occupants

Other Measures

- Prevent public access to mechanical areas and roofs
- Implement security measures, such as guards, alarms, and cameras to protect vulnerable areas.
- Isolate lobbies, mailrooms, loading docks, and storage areas

Other Measures

- Secure return air grills
- Restrict access to building operation systems by outside personnel/contractors
  - Escort through building, check work
- Restrict access to building information
  - Release blueprints, emergency operational procedures, etc to authorized personnel only

Ventilation and Filtration NIOSH Recommendations

- Evaluate HVAC system components with respect to vulnerability to introduction of CBR agents
- Evaluate HVAC control options
- Energy Management (normal operation)
  - Emergency operation (smoke purge by zone)
  - Master control - shutdown supply, full exhaust, pressure stairwells, etc. to minimize the spread
  - Train operators (minimize impact for Infection Control)

Ventilation and Filtration Assess Filtration

- Increasing filter efficiency may reduce consequences of internal or external release
- Assess filter bypass from leakage around filter frames (poor seals)
- Evaluate current filter efficiencies
- Note - Particulate filter are not effective for gases and vapors (require absorption e.g. activated carbon)

Add'l HVAC Recommendations

- Low-Leakage, Fast Acting Dampers When HVAC shutdown –
  - outside air may still be drawn in due to pressure difference
- Building Air Tightness
  - Infiltration due to leaks in building envelop
  - Climatic pressure gradients

Part III - Containment, Cleanup, Remediation

- IC concerns focusing on addressing damage following major incident:
  - Safety evaluation;
  - Water removal;
  - Inspections/repair/replace infrastructure
  - General inventory of areas damaged
  - Mold remediation
  - Quality control and testing before reoccupation

Part III - Containment, Cleanup, Remediation

- Safety evaluation- overall services lost/damaged
  - Structural integrity
  - Electrical system damage-
  - Water and Sewer damage
  - Fire emergency system damage (fire detection, automatic alarm reporting
  - Mechanical system (Ventilation; isolation, lab and research fume removal; pharmacy clean areas)

Part III - Containment, Cleanup, Remediation Part

- Water removal
  - Sewerage service
  - Dishwashing
  - Laundry—if on-site
  - Cooking
  - Fire sprinkler service
  - Potable (drinking) water
  - Spill cleanup
  - Patient bathing

Part III - Containment, Cleanup, Remediation

- Inspections/repair/replace infrastructure
  - Mechanical systems
  - Water systems
  - Fuel sources
  - Medical gas and vacuum systems
  - Electronic communication systems

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Design Specs for Ventilation… Specifications -Commissioning Guidelines

Specifications	Airborne Infection Isolation (AII)	Protective Environment (PE)
Air pressure	Negative (air flow in)	Positive (air flow out)
Room air changes	≥ 6 ACH for existing areas; ≥ 12 ACH for new construction or renovation	> 12 ACH
Sealed	Yes	Yes
Filtration on supply air	90% (dust-spot testing)	99.97% (HEPA)
Recirculation	100% exhaust or 99.97% (HEPA)	Yes
Pressure differential	≥0.01" Water gauge	≥0.01" Water gauge

Part III - Containment, Cleanup, Remediation

- **General inventory of damaged areas/surfaces**
  - Furniture salvageable?
  - Supplies salvageable?
  - Electrical medical equipment
  - Structures- (Wallboards, ceiling tiles etc)
  - Moisture levels evaluated?
  - Damaged structures repaired and cleaned?

Part III- Containment, Cleanup, Remediation

- **Mold remediation**
  - Detection
    - Odors & sight
    - Sampling methods/purpose
  - Decontaminate
  - Cleanup
  - buildback

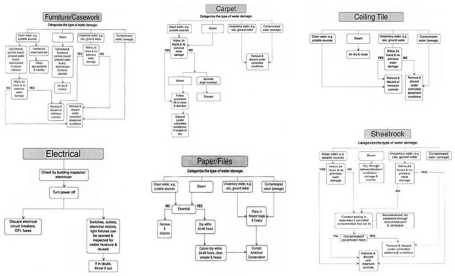
Part III- Containment, Cleanup, Remediation

- **Quality control and testing** before reoccupation
  - Depends on area occupancy
  - Greater emphasis on continuous occupancy
  - Work area
  - Patient care

Moisture detectors are useful decision makers for water detection & drying

Keep moisture content <20% & <90%RH
Maintain air movement
Remove moisture physically
or by evaporation

Water Intrusion Algorithms



www.dehs.umn.edu/iaq

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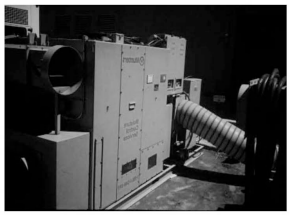
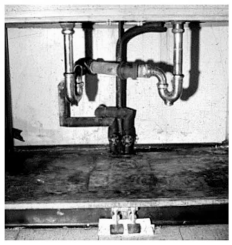


Large leaks may require drying with dehumidifiers equipment

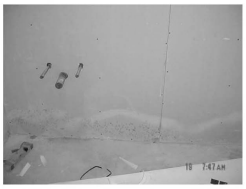
GOAL

<20% water content
<95% RH

Local dehumidifiers will help control condensation



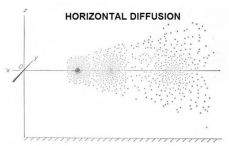
Mold growth should be expected with RH >90% and water content of material >20%



Mold recognition is visual and olfactory. If dehumidification is hindered expect odors.

Infrared cameras are useful for moisture detection

Mold Management Equals Spore Release Control

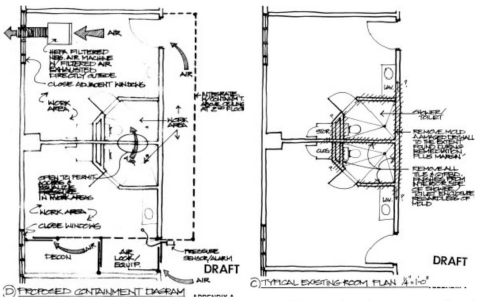


When the source is dry the spores fly!
Containment or open buildings will help manage the ae

Training to mitigate mold issues during construction in healthcare.

Training provides IC know how with methods to minimize exposure.

Training needs constant up-dating to be relevant with healthcare construction.



-Contamination area defined
-Decontamination method
-Exhaust ventilation

Particle counters tell rank order
Pressure gauges give air velocity
Balancing hoods verify air exchanges

These parameters should be kept stable & should be checked when changes or adjustments in the HVAC system occur.

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CDC EIC MMWR JUNE 6, 2003

Table 6. Engineered specifications for positive- and negative pressure rooms*

	Positive pressure areas (e.g., protective environments [PE])	Negative pressure areas (e.g., airborne infection isolation [AII])
Pressure differentials	> +2.5 Pa§ (0.1" water gauge)	> -2.5 Pa (0.1" water gauge)
Air changes per hour (ACH)	>12	≥12 (for renovation or new construction)
Filtration efficiency	Supply: 99.97% @ 0.3 μm DOP¶ Return: none required**	Supply: 90% (dust spot test) Return: 99.97% @ 0.3 μm DOP¶ ⊥
Room airflow direction	Out to the adjacent area	In to the room
Clean-to-dirty airflow in room	Away from the patient (high-risk patient, immunosuppressed patient)	Towards the patient (airborne disease patient)
Ideal pressure differential	> + 8 Pa	> - 2.5 Pa

* Material in this table was compiled from references 35 and 120. Table adapted from and used with permission of the publisher of reference 35 (Lippincott Williams and Wilkins).

§ Pa is the abbreviation for Pascal, a metric unit of measurement for pressure based on air velocity; 250 Pa equals 1.0 inch water gauge.

¶ DOP is the abbreviation for dioctylphthalate particles of 0.3 μm diameter.

** If the patient requires both PE and AII, return air should be HEPA-filtered or otherwise exhausted to the outside.

⊥ HEPA filtration of exhaust air from AII rooms should not be required, providing that the exhaust is properly located to prevent re-entry into the building.

AIA & ASHRAE DESIGN GUIDELINES FOR VENTILATION

Summary Healthcare HVA methods

- Validate for existing conditions
  - Probability, vulnerability & response
- Communication guidelines essential
- Training for response
  - Events include emerging infection, chemical
- Source management essential
- Water damage control protocols needed
- Prepared personnel will volunteer during events

The Next Few Teleclasses

November 15	**An Approach to Outbreak Management - Using Biostats to Clobber Bugs** … with Dr. Dick Zoutman, Queen's University
November 29	**Effective Infection Prevention in 3-5 Steps** … with Allen Soden, Deb Ltd.
December 6	**Infection Control in the Living and the Dead - The Angola Marburg Outbreak** … with Prof. Adriano Duse, U. of Witwatersrand, South Africa
December 13	**Water Quality Issues Pertaining to Medical Device Reprocessing** … with Dr. Michelle Alfa, St. Boniface Hospital, Winnipeg

For the full teleclass schedule - www.webbertraining.com

For registration information: www.webbertraining.com/howto1.php

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