Healthcare Associated Infections After Major Flooding ... Expect the Unexpected

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webbertraining.com June 25, 2014

Objectives

- Infections after major flood (mostly nosocomial)
- How to prevent it?
- Lessons learned

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Natural disater

- Volcanic eruption
- Earthquake
- Cyclone or Hurricane
- Avalanche
- Flood & Tsunami
- Drought
- Forest fire or Bushfire
- landslides
- Tidal wave
- Environmental pollution
- Snow storms
- Epidemic Disease

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Political disaster

Political disaster

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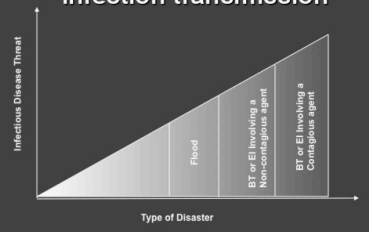
Disasters are Increasing

All disasters can have an impact on infection transmission



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Impact of Flood

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Impact of Flooding

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Impact of Flooding

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Objectives

- Healthcare Associated Infections After Flooding
  - Fungal Infections
  - Bacterial Infections
  - Mycobacterial Infections
- Infection Control After Flooding

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Healthcare Associated Infections After Flooding

Fungal Infections

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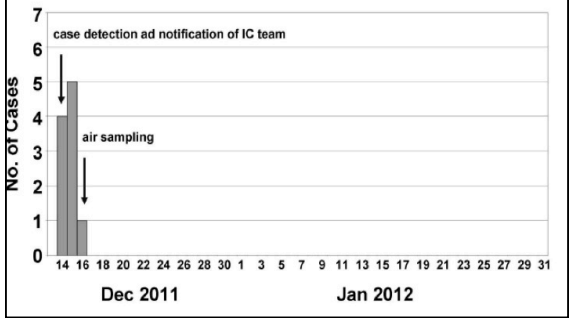
Emergence of Pseudo-outbreak due to *Penicillium* spp.



Obtaining Outbreak Data

Table 1. Demographic and Clinical Characteristics of 10 Hospitalized Patients With Postflood Pseudofungemia With *Penicillium* Species Identified During a 72-Hour Interval

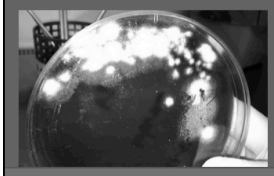
Case	Age/Sex	Location Where BCs Were Drawn (Positive Sets)	Underlying Diseases	Final Diagnosis[a]	Hospital Length of Stay (d)
1	84/F	ED (1)	HTN	Aspiration pneumonia	4
2	54/M	ED (1)	None	CAP	2
3	5/M	ED (1)	None	Severe tonsillitis	1
4	65/M	ED (2)	None	CAP	2
5	76/F	ED (2)	HTN, DM	Viral gastroenteritis	1
6	45/F	ED (1)	DM	DKA	4
7	71/M	ED (1)	HTN, CVA	Viral syndrome	2
8	30/F	ED (2)	None	Dengue fever	2
9	36/M	ED (1)	None	Viral gastroenteritis	1
10	41/F	ED (1)	None	Leptospirosis	3

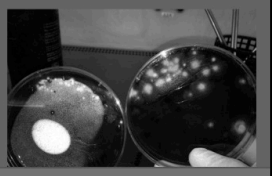
Postflood Pseudofungemia Due to *Penicillium* Species

Anucha Apisarnthanarak,[1] Thana Khawcharoenporn,[1] Kanokporn Thongphubeth,[1] Chananart Yuekyen,[1] Suwat Damrin,[2] Narissara Mungkornkaew,[3] and Linda M. Mundy[4]

CID 2012:55 (15 July)

Pseudo-outbreak may seem benign, but it is a big deal for some patient populations.
It also impact physicians' decision.



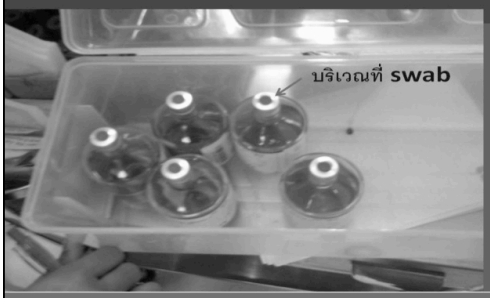


What will you do in patients who will received hardware after surgery or CVT surgery?

It will impact doctors' decision to treat immunocompromised hosts (e.g., febreile neutropenia)

Fungal infections is also in differential diagnosis for NI in units with high fungal burden in the air

What we found from the field?



Air sampling in ER confirmed *Penicillium* species in the areas affected (1 area), but not other areas (3 areas)

Interventions

- Area decontamination start with manual clean
- Hydrogen peroxide vaporizer
- Implement air filtration at the site
- Observed IC compliance to withdrawn B/C

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When to Use these Special Approaches for Room Decontamination?

- Special high risk areas (lab, OR, vaccine lab, etc)
- Adjunct measure to control outbreak of MDROs
- Terminal care in private patient room preoccupied with MDRO patients particularly in high risk units (BMT)
- In special situations (e.g., room decontamination for bioterrorism such as anthrax) and EID quarantine room, flood
- Sensitive equipment that may be difficult to disinfect after cleaning

Because of potential for inadvertent exposure to people and damage to surfaces or equipments, chemical fumigants should be used when the benefits clearly exceed the risks.

AHA Position Paper

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New Approach to Room Decontamination

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Effectiveness of UV Irradiation

		UV-C line of sight						
		Total		Direct		Indirect		
Organism	Inoculum	No. of samples	Decontamination, $\log_{10}$ reduction, mean (95% CI)	No. of samples	Decontamination, $\log_{10}$ reduction, mean (95% CI)	No. of samples	Decontamination, $\log_{10}$ reduction, mean (95% CI)	*P*
MRSA	4.88 $\log_{10}$	50	3.94 (2.54–5.34)	10	4.31 (3.13–5.50)	40	3.85 (2.44–5.25)	.06
VRE	4.40 $\log_{10}$	47	3.46 (2.16–4.81)	15	3.90 (2.99–4.81)	32	3.25 (1.97–4.62)	.003
MDR *A. baumannii*	4.64 $\log_{10}$	47	3.88 (2.59–5.16)	10	4.21 (3.27–5.15)	37	3.79 (2.47–5.10)	.07
C. difficile spores	4.12 $\log_{10}$	45	2.79 (1.20–4.37)	10	4.04 (3.71–4.37)	35	2.43 (1.46–3.40)	<.001

William A. Rutala, PhD, MPH; Maria F. Gergen, MT (ASCP); David J. Weber, MD, MPH

INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY OCTOBER 2010

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Efficacy of UV Light for Moulds

- At certain wave length, UV light break molecule bond in DNA destroying an organism
- UV-C has characteristic wave length of 200-270 nm, which lies a germicidal activity portion of EM spectrum 200-320nm

More to Less Susceptible

- *S. aureus*
- *Strep Gr A*
- *E. coli*
- *Ps. Aeruginosa*
- *Mycobacterium spp*
- *Bacillus spp.*
- *Aspergillus spp.*
- *Pennicillium spp.*

Martin, et al. 2008

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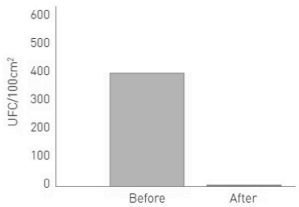
HP activity for Fungus

Figure 1. Comparison of *Aspergillus spp* contamination in a hospital laboratory before and after decontamination with dry-mist hydrogen peroxide. *(P<0.05)*



Source*: Marty N, Cavalié L, Conil J, Roques C. Dry fog disinfection: an assessment of microbiological efficacy and practical advantages. *Revue Hygienes* 2007;15:317-20.

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HP activity for Fungus

Figure 1. Comparison of *Aspergillus spp* contamination in a hospital laboratory before and after decontamination with dry-mist hydrogen peroxide. *(P<0.05)*

Conclusion: The authors concluded that the dry-mist hydrogen peroxide decontamination system should provide facilities with an effective method for controlling the spread of infectious diseases, noting that the method can be used both preventatively during routine decontamination and as a treatment during infectious disease outbreaks.

Source*: Marty N, Cavalié L, Conil J, Roques C. Dry fog disinfection: an assessment of microbiological efficacy and practical advantages. *Revue Hygienes* 2007;15:317-20.

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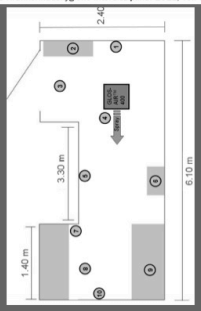
Decontamination of room air and adjoining wall surfaces by nebulizing hydrogen peroxide

GMS Krankenhaushygiene Interdisziplinär 2011, Vol. 6(1), ISSN 1863-5245



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Decontamination of room air and adjoining wall surfaces by nebulizing hydrogen peroxide

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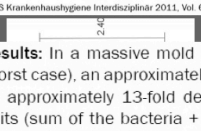
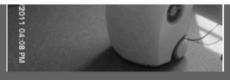


Results: In a massive mold infestation resulting from water damage (worst case), an approximately 9-fold decrease in the mold content and an approximately 13-fold decrease in the number of colony-forming units (sum of the bacteria + fungi) could be detected in the room air immediately after the nebulizing was finished. Even in samples of wall and joint plaster, the molds were reduced, although to a distinctly lesser extent.

By indoor nebulization of 5–6% H_2O_2, *A. brasiliensis* was reduced >4 log on vertical and horizontal surfaces.



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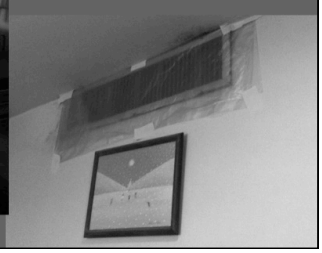
Introduction of HP



Introduction of HP

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Introduction of HP

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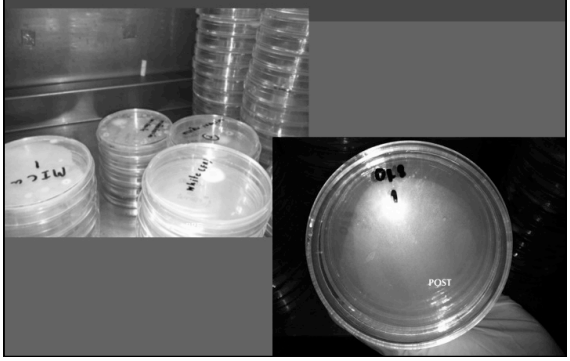
Outcomes (close units)



Interpret Results with Cautions

- Settle plate is a non-standard culture method (no standard cut off)
- Detection of moulds depends on air currents
- Air cultures for mould do not always accurately indicate the spore load
- Don't get consistent reliable information
- Several expert suggest against use of settle plate culture

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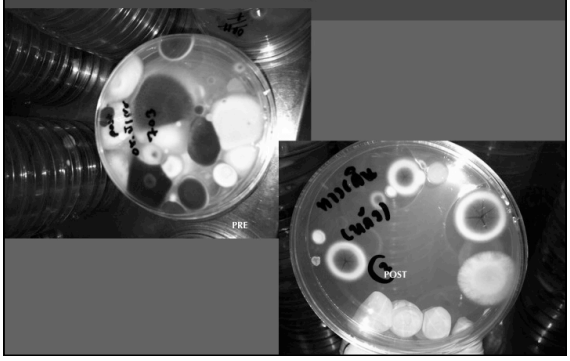
Outcomes (open units)



This finding is not surprising

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Does Fumigation with Other Products Produce the same Results?

Table 1. Serial Air Bioburden Measurements of Bacteria and Fungi in the Patient Rooms and Nursing Station of a Hospital's Negative-Pressure Unit After Fumigation With a Quaternary Ammonium Salt–Based Solution Combined With 2 Alcohols

Duration After Fumigation	Bacterial Air Bioburden (CFU/m^3)					Fungal Air Bioburden (CFU/m^3)				
	PR 1	PR 2	PR 3	PR4	NS	PR1	PR2	PR3	PR4	NS
6 hours	840	660	580	680	900	534	553	585	536	556
Day 1	30	90	90	80	120	147	147	134	134	234
Day 7	30	90	120	120	200	147	130	147	100	234
Day 14	30	90	330	180	470	335	236	336	450	326

Abbreviations: CFU, colony-forming unit; NS, nursing station; PR, patient room.

Anucha Apisarnthanarak,[1] Sanee Wongcharoen,[1] and Linda M. Mundy[2]
[1]Division of Infectious Diseases, Faculty of Medicine, Thammasat University Hospital, Pathumthani, Thailand; and [2]GlaxoSmithKline, Collegeville,

CID • CORRESPONDENCE

Lessons Learned

- Air decontamination using vapor/aerosolize is only a part of room decontamination and cannot be used as stand-alone intervention
- Other interventions that might help include through cleaning, use of filter/HEPA filter/UV light

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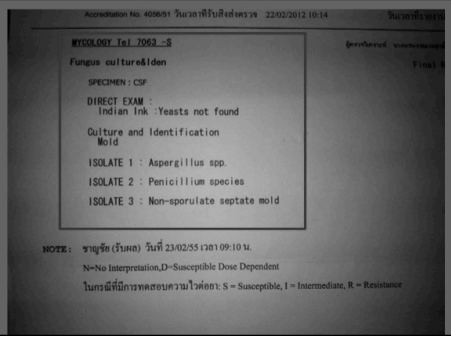
What happen 6-mo after Flood



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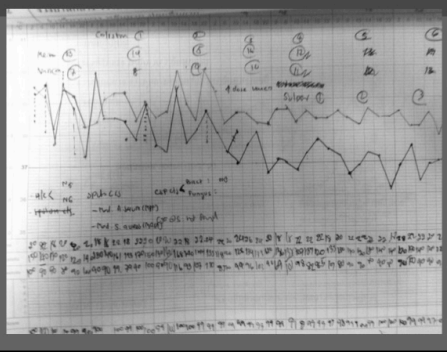
What happen 6-mo after Flood



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What happen 6-mo after Flood

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6-Mos Post Flood

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6-Mos Post Flood

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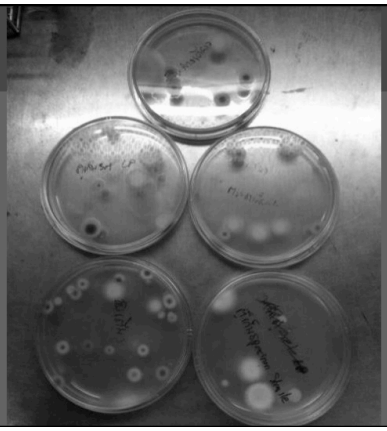

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Pseudo-outbreak/infection lead to unnecessary work up and antifungal exposure

Apisarnthanarak A, et al. Post-flood pseudo-meningitis. ICHE 2012

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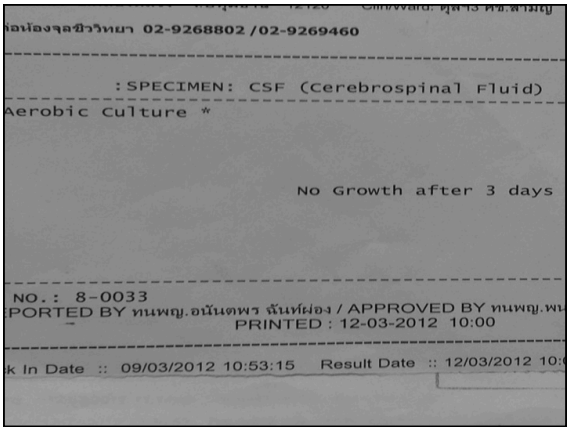

ทอน้องจุลชีววิทยา 02-9268802 /02-9269460

:SPECIMEN: CSF (Cerebrospinal Fluid)

Aerobic Culture *

No Growth after 3 days

NO.: 8-0033

PORTED BY ทนพญ.อนันตพร จันท์ผ่อง / APPROVED BY ทนพญ.พ

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Six Outbreak Investigations for Moulds

Table 1. Investigation of cases with mold and air sampling measurements from six in-patient units after re-opening hospital.

Inpatient Unit	1-31 December 2011				1-31 January 2012					1-29 February 2012				
	Unit open (date)	ITFB	Fungal Type*	OB	TFB	Fungal Type	TFB	Fungal Type	OB	TFB	Fungal Type	TFB	Fungal Type	OB
Unit 1	12/12/11	840	P, A, Ph, S	Yes[a]	545	P, A	656	A, P	No	565	A, P	443	A, P	No
Unit 2	12/12/11	1,980	A, F, P	Yes[b]	756	A, P	766	A, F	No	656	A, F	576	A, P	No
Unit 3	12/12/11	1,150	A, P, Ph	Yes[c]	768	A, Ph	565	A, P	No	443	A, Ph, F	323	A, F	No
Unit 4	12/12/11	4,270	P, A, Ph	Yes[d]	765	P, A, Ph	543	A, P, Ph	No	442	P, A	443	P, A	No
Unit 5	2/14/12	980	A, F, P									835	A, P	Yes[e]
Unit 6	3/10/12	474	A, P											

Six Outbreak Investigations for Moulds

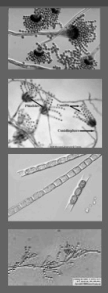
Table 1. Investigation of cases with mold and air sampling measurements from six in-patient units after re-opening hospital.

By multivariate analysis, initial fungal bioburden >500 CFU/m3 was associated with pseudo-outbreak due to moulds (aOR = 4.71; *P* =0.02)

Detection of Fungal in the Air by Non-standard Method

Predominant Fungus

- *Aspergillus spp.*
- *Pennicillium spp.*
- *Microspora spp.*
- *Paecilomyces spp.*



Hospital Pre- Vs. Post-

Initial Air Quality Check After Flood

Air quality characteristics	All rooms (N =68)	Open-ventilation patient care areas[1] (N = 39)	Closed-ventilation patient care areas[2] (N = 29)	*P* Value
Relative humidity (%, median, range)	60.9 (56.9-72.4)	60.3 (57.3-72.4)	61.6 (56.9-71.9)	0.24
Temperature (°C, median, range)	26.6 (20.0-28.6)	27.6 (25.5-28.6)	25.9 (20.0-28.2)	**0.001**
Carbon dioxide (ppm, median, range)	537.5 (492.0-707.0)	524.0 (504.0-594.0)	554.0 (492.0-707.0)	0.09
Total bacterial bioburden (CFU/m^3, median, range)[3]	654 (120-8,360)	880 (140-8,360)	475 (120-1980)	**0.04**
Total fungal bioburden (CFU/m^3, median, range)[3]	590 (160-4,400)	775 (200-4,400)	430 (160-2680)	**0.05**

Initial Air Quality Check After Flood

Air quality characteristics	All rooms (N =68)	Open-ventilation patient care areas[1]	Closed-ventilation patient care areas[2]	*P* Value
Re				
Te				
Ca				
To				
Total fungal bioburden (CFU/m^3, median, range)[3]	590 (160-4,400)	775 (200-4,400)	430 (160-2680)	0.05

High bacterial and fungal bioburden >500 CFU/mm3 were detected only in units with excess humidity (100% vs. 0%; *P*<0.001)

All areas with fungal pseudo-outbreak had excess humidity

By multivariate analysis, first floor units were associated with excess fungal and bacterial bioburden (aOR = 1.16; *P*<0.001)

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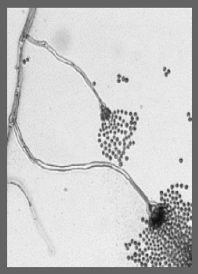
Invasive Infections: Aspergillus

- Ubiquitous fungi
  - *Aspergillus fumigatus* (90% of disease)
- High risk patients
  - Hematopoietic stem cell transplant recipients
  - Solid organ transplant patients
  - Prolonged neutropenia
  - Preterm neonates



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Stem Cell Transplant Units and Aspergillus Outbreaks

- Causes
  - no HEPA filtration
  - poor maintenance of air filters
  - poorly sealed windows and walls
  - positive pressure not maintained
  - no patient precautions when outside of unit
  - construction in or near hospital
  - disturbance of normally closed spaces
  - often unknown

Surgical site infections and *Aspergillus spp.*

- Examples in literature
  - Endocarditis or aortitis following cardiac surgery
  - Burn wound infections
  - Prosthetic joint replacement
  - Vascular grafts
- Source of aspergillus not always known
  - Heavy contamination of OR air intake
  - Contamination of insulation or air filters
  - Contaminated irrigating fluids or wound dressings

Pasqualotto AC and Denning DW. Clin Microbiol Infect. 2006;12(11):1060-76

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Healthcare Associated Infections After Flooding

Bacterial Infections

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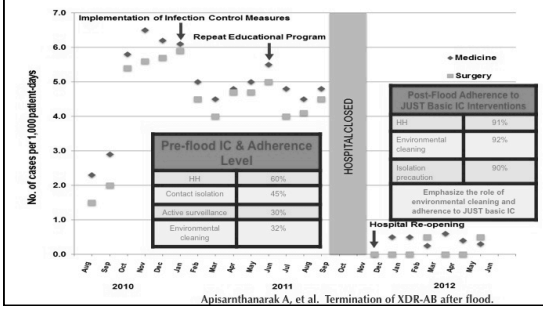
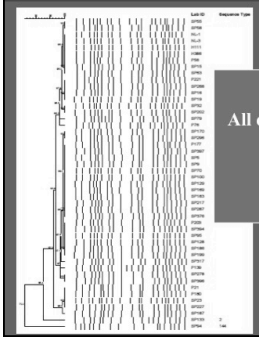
Termination of XDR-Acinetobacter: Lessons Learned



Apisarnthanarak A, et al. Termination of XDR-AB after flood.

Control of *Acinetobacter* outbreak after floods



All except three belong to the same clone

Courtesy of Dr. Hsu Li Yang

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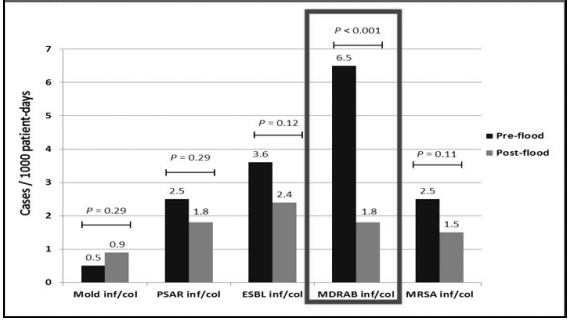
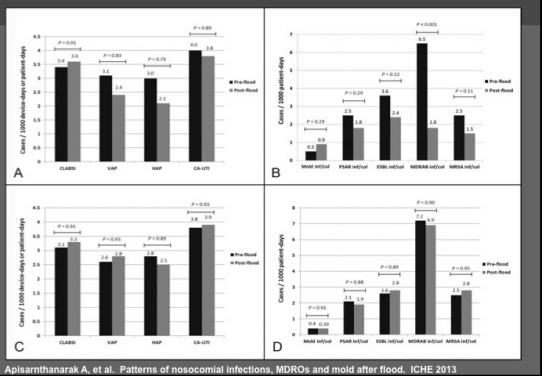
This is Not a Local Issues: A Survey Was Made to 101 Hospitals in 15 Provinces



Nosocomial Infections Post-Flood



Apisarnthanarak A, et al. Patterns of nosocomial infections, MDROs and mold after flood. ICHE 2013

Surveillance After Flood

Traditional diseases:

- Leptospirosis
- Hepaitits A
- Dengue hemorrhagic fever
- Pneumonia (e.g., Legionella)
- Measle
- TB
- Infected conjunctivitis
- Viral diarrhea

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Always monitors for possible diseases after flood

- We identified 5 cases of melioidosis occurred in a month after flood (melioidosis never thought to be related to diseases after flood)
- Unique feature of these patients: No traditional underlying diseases, quick presentation (within 5 days), high melioid titer and had fulminant clinical course

Apisarnthanarak A, et al. IJID 2012

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Table 1
Clinical characteristics, laboratory data, and treatment outcomes of four patients with melioidosis associated with flood exposure

Case	Underlying conditions/diagnosis	*Burkholderia pseudomallei* IHA titer[a]	Days from presentation to admission: median	Days from admission to receipt of appropriate antibiotics: median	Treatment	Survived
1	COPD, HTN/CAP	1:2048	2	2	Imipenem	Yes
2	None/CAP	1:4096	5	2	CAZ + TMP-SMX	Yes
3	None/aspiration pneumonia	1:8192	5	2	CAZ + TMP-SMX	Yes
4	None/aspiration pneumonia	1:4096	5	2	CAZ + TMP-SMX	Yes
5	None/skin and soft tissue infection	1:2048	7	4	CAZ + TMP-SMX	Yes

IHA, indirect hemagglutination assay; COPD, chronic obstructive pulmonary disease; HTN, hypertension; CAP, community-acquired pneumonia; CAZ, ceftazidime; TMP-SMX, trimethoprim-sulfamethoxazole.

[a] Positive if >1:80 for persons residing in non-endemic regions.

Healthcare Associated Infections After Flooding

Mycobacterial Infections

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Outbreak of *Mycobacterium porcinum* linked to water supply

- *M. porcinum* is a rapid-growing mycobacterium
- UTMB found 26 patients between 2005-2010
  - Most cases before hospital flooding
  - 11 patients considered infected (4 community and 7 hospital-acquired)
  - Hospital water and ice samples collected immediately after flooding
    - 86 (62%) of 139 water samples grew rapid-growing mycobacterium – of those tested 50% were *M. porcinum*
- *M. porcinum* detected in tap water from 80% of homes tested in same city as hospital
- The majority of patient isolates were closely related to hospital and residential water isolates by PFGE

Brown-Elliott BA et al. *J Clin Microbiol.* 2011;49:4231-8.

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Surveillance for HCWs Health

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Medical issues related to mold exposure

- Exposure to inhaled spores, fungal fragments, and mycotoxins
- Diseases
  - Allergic reactions
  - Toxic effects
  - Invasive infections (immunocompromised)
- Reactions more likely to occur with either high fungal load or chronic exposure

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Mold exposure – Allergies and asthma

- 10% of general US population have IgE antibodies to common inhaled molds
- Sensitization to fungi, especially *Alternaria alternata*, linked to the presence and severity of asthma
- No clear data for mold causing allergic rhinitis

Bush RK et al. *J Allergy Clin Immunol.* 2006;117:326-33.

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Mold exposure – Rare lung diseases

- Allergic bronchopulmonary aspergillosis
  - IgE-mediated disease in asthma and cystic fibrosis patients
  - Wheezing, eosinophilia, pulmonary infiltrates, chronic cough with mucus plugs
- Hypersensitivity pneumonitis
  - High-dose and / or prolonged exposure
  - Fever, chills, malaise, nausea, cough, chest tightness, and dyspnea without wheezing

Bush RK et al. *J Allergy Clin Immunol.* 2006;117:326-33.

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Chronic asbestos exposure

Mesothelioma
Asbestosis
Need to monitor HCWs

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Conclusions

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Healthcare-associated infections and their prevention after extensive flooding

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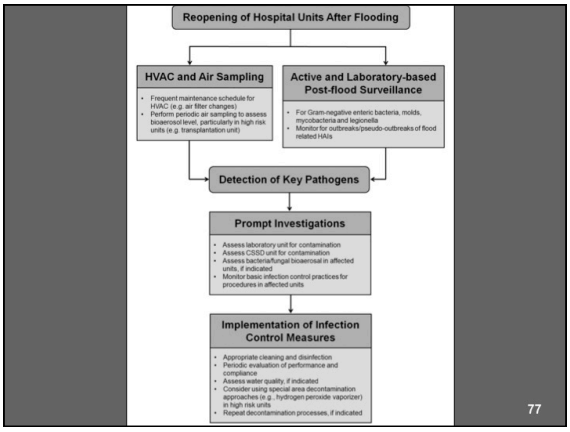
Purpose of review
This review will focus on the epidemiology of healthcare-associated infections (HAIs) after extensive blackwater flooding as well as preventive measures.

Recent findings
There is evidence suggesting an increased incidence of HAIs and pseudo-outbreaks due to molds after extensive flooding in healthcare facilities. However, there is no strong evidence of an increased incidence of typical nosocomial infections (i.e., ventilator-associated pneumonia, healthcare-associated pneumonia, central line-associated bloodstream infection and catheter-associated urinary tract infections). The prevalence of multidrug-resistant organisms may decrease after extensive flooding, due to repeated and through environmental cleaning prior to re-opening hospitals. Contamination of hospital water sources by enteric Gram-negative bacteria (e.g., *Aeromonas* species), *Legionella* species and nontuberculous *Mycobacterium* species in flood-affected hospitals has been reported. Surveillance is an important initial step to detect potential outbreak/pseudo-outbreak of HAIs. Hospital preparedness policies before extensive flooding, particularly with environmental cleaning and mold remediation, are key to reducing the risk of flood-related HAIs. These policies are still lacking in most hospitals in countries that have experienced or are at risk for extensive flooding, which argues for nationwide policies to strengthen preparedness planning.

Summary
Additional studies are needed to evaluate the epidemiology of flood-related HAIs and the optimal surveillance and control methods following extensive flooding.

Table 1. Organisms resulting in healthcare-associated infections after extensive flooding, risk factors and preventive measures

Type of organism/references	Specific pathogens	Risk factors	Preventive measures
Bacteria [12–14,23,24••]	Water borne enteric GNB (e.g., *Aeromonas* spp., *Vibrio* spp.)	Contamination of water source	Periodic portable water quality assessment and investigation for point source, if indicated
		Contamination of internal plumbing	Environmental cleaning
		Contaminated wound	
	Legionella spp.	Contamination of water source	Periodic portable water quality assessment and investigation for point source
		Contamination of internal plumbing	Remediate with chlorine dioxide and then copper–silver ionization of water sources
	MDROs[a]	Hospital with lack of environmental cleaning policy	Repeated and through environmental cleaning
		Lapses in basic infection control practices	Consider using special approaches (e.g., hydrogen peroxide vaporizer) in high risk units
Mycobacterium spp. [25–29]	*Nontuberculous Mycobacterium* spp.	Contamination from laboratory	Periodic water quality assessment
		Contamination of water source	Remove contaminant from water source, if detected
		Contamination of ice machine and drinking water	Prompt investigation after case detection
		Contamination in patient sputum	
Molds [35–37]	Environmental molds (e.g., *Aspergillus* spp., *Penicillium* spp., *Fusarium* spp.)	High fungal air bio-burden	Repeated and through environmental cleaning
		No HEPA filtration	Serial monitoring of fungal air bio-burden
		Contaminated HVAC system	Consider using special approaches (e.g., hydrogen peroxide vaporizer) in high risk units
		Poor maintenance of air filtration	Contain construction sites
		Construction/Demolition in/near hospital	Scheduled maintenance for HVAC/HEPA system



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