

Healthcare Associated Infections After Major Flooding: Expect the Unexpected

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Objectives

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



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Anucha Apisarnthanarak, MD

☐ **Personal CV & Photos**

☐ **Presentation Handouts**

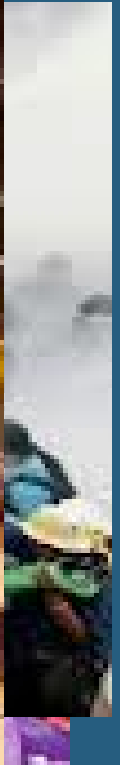
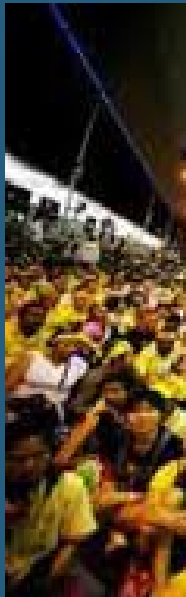
- ☐ 1-5-12 Richmond outbreak talk
- ☐ 27-4-12 Richmond IC Lab
- ☐ 24-4-12 Richmond IC Flood
- ☐ 10-3-12 Hong Kong ID Society
- ☐ 9-7-12 NNIG 2012
- ☐ 21-2-12 ICN forum
- ☐ 26-1-12 PM Pharmacotherapy
- ☐ 26-1-12 Area Decontamination
- ☐ 21-1-12 MSD IC talk
- ☐ 19-1-12 . MDR IC
- ☐ 17-1-12 . candida SSI
- ☐ 6-1-12 TU Flood workshop

www.prakit.com/idtu

Natural disaster

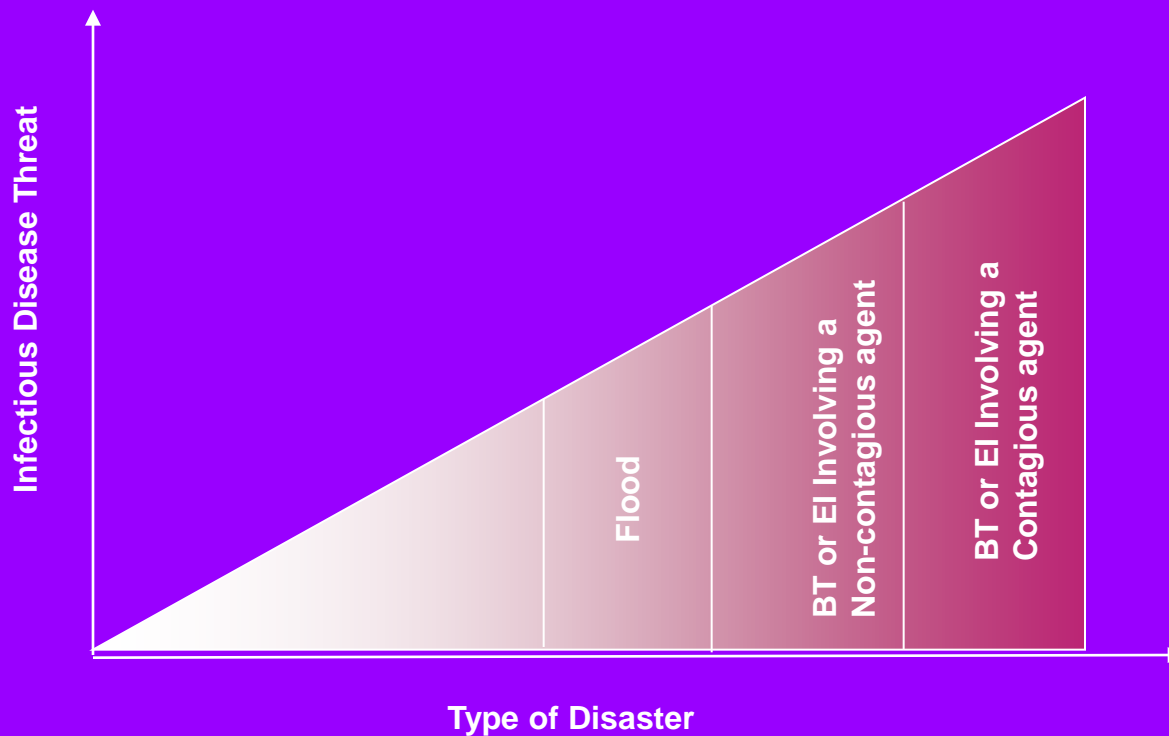
- Volcanic eruption
- Earthquake
- Cyclone or Hurricane
- Avalanche
- Flood & Tsunami
- Drought
- Forest fire or Bushfire
- landslides
- Tidal wave
- Environmental pollution
- Snow storms
- Epidemic Disease

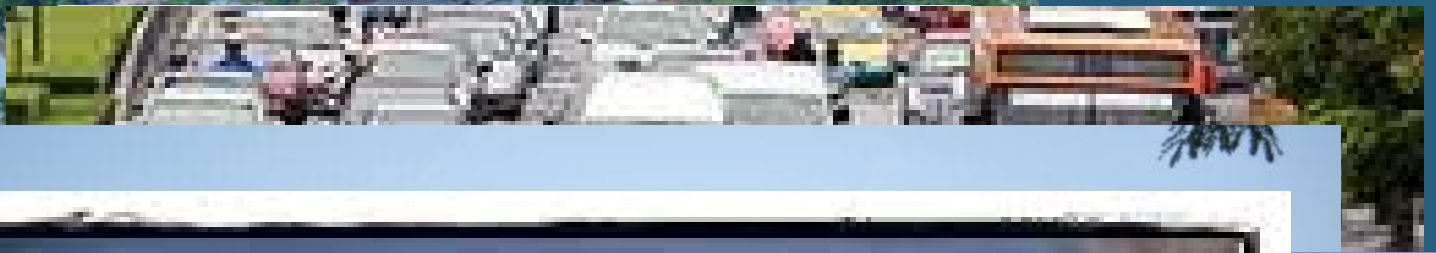
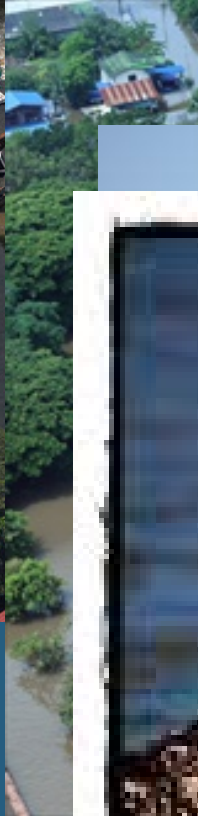
Political disaster



Disasters are Increasing

All disasters can have an impact on infection transmission





Impact of Flood



Impact of Flooding



Impact of Flooding



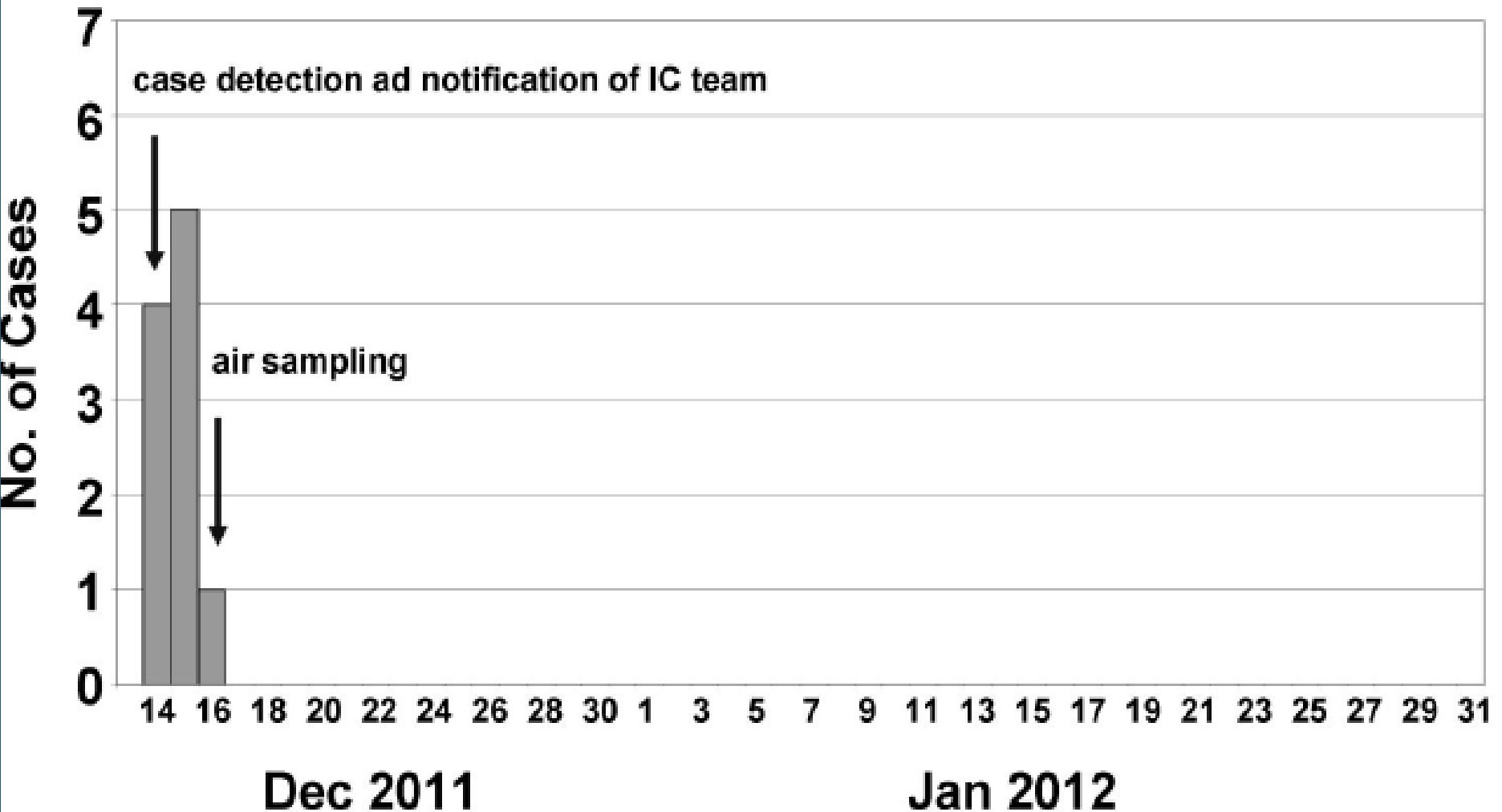
Objectives

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

Healthcare Associated Infections After Flooding

Fungal Infections

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 Damnin,² Narissara Mungkornkaew,³ and Linda M. Mundy⁴

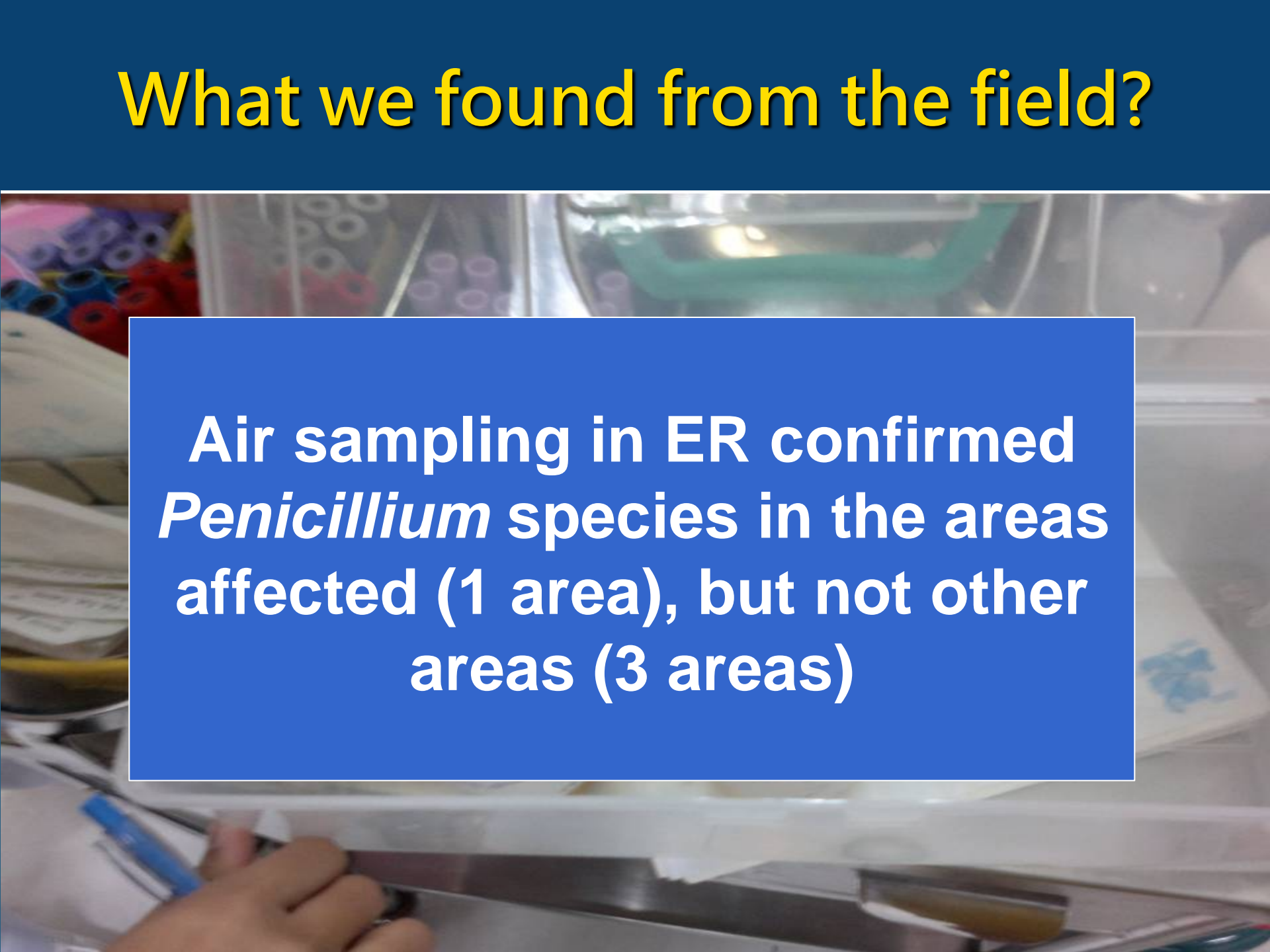
Pseudo-outbreak may seem benign, but it is a big deal
for some patient populations.
It also impact physicians' decision.

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

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

New Approach to Room Decontamination



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 <i>A. baumannii</i>	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
<i>C. difficile</i> 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

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

HP activity for Fungus

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

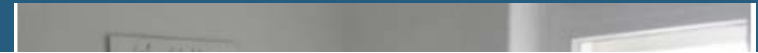
Conclusion: The authors concluded that the dry-mist hydrogen peroxide decontamination system should provide facilities with an effective method for controlling the spread of infectious diseases, noting that the method can be used both preventatively during routine decontamination and as a treatment during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

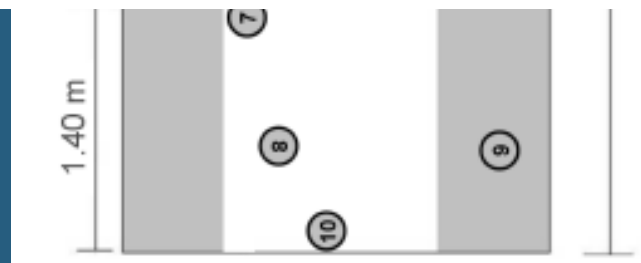
Decontamination of room air and adjoining wall surfaces by nebulizing hydrogen peroxide

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



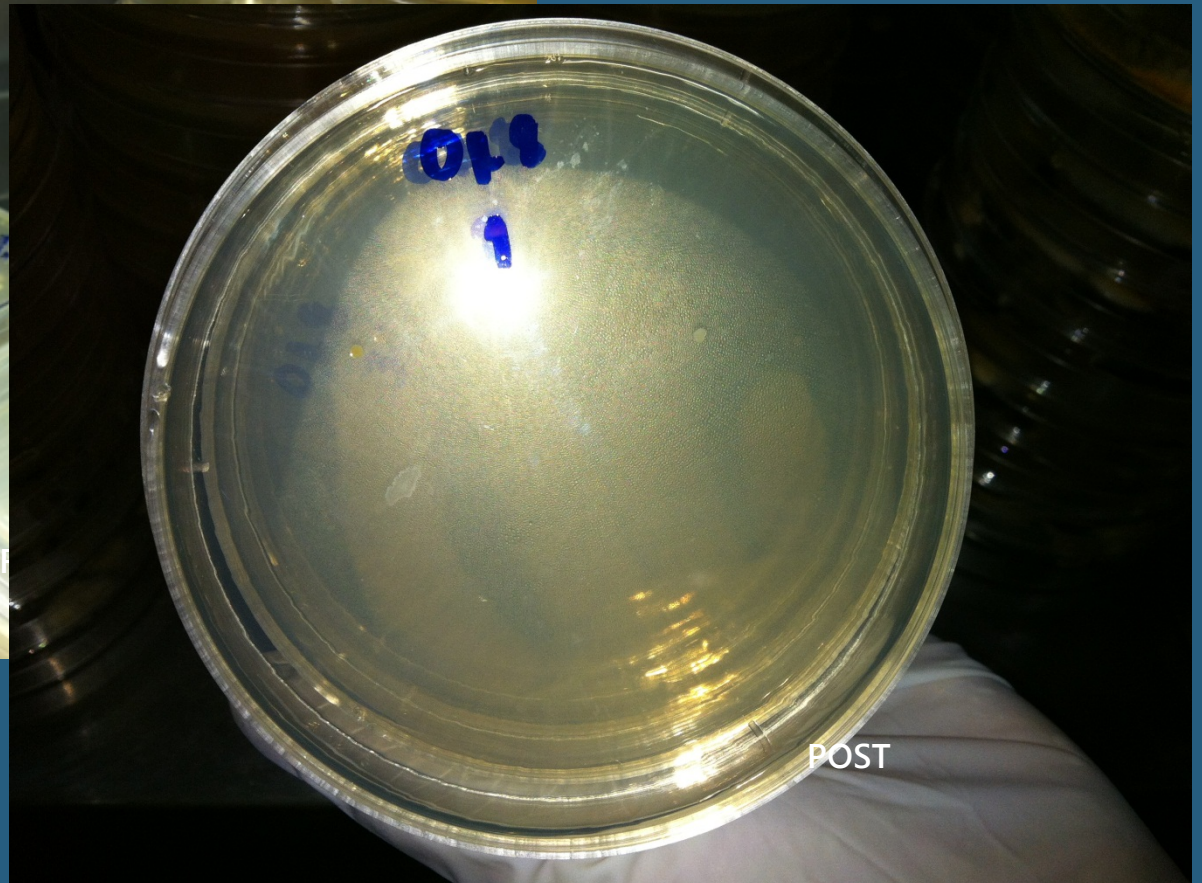
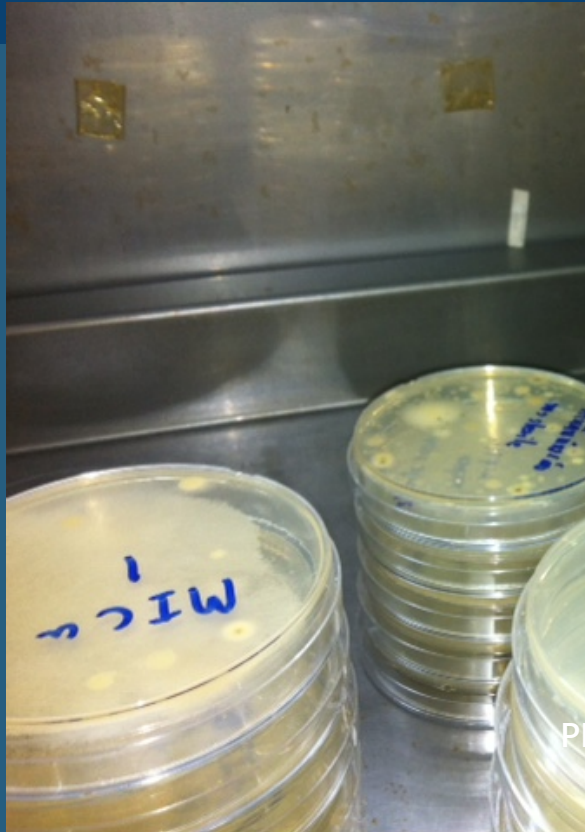
Results: In a massive mold infestation resulting from water damage (worst case), an approximately 9-fold decrease in the mold content and an approximately 13-fold decrease in the number of colony-forming units (sum of the bacteria + fungi) could be detected in the room air immediately after the nebulizing 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.





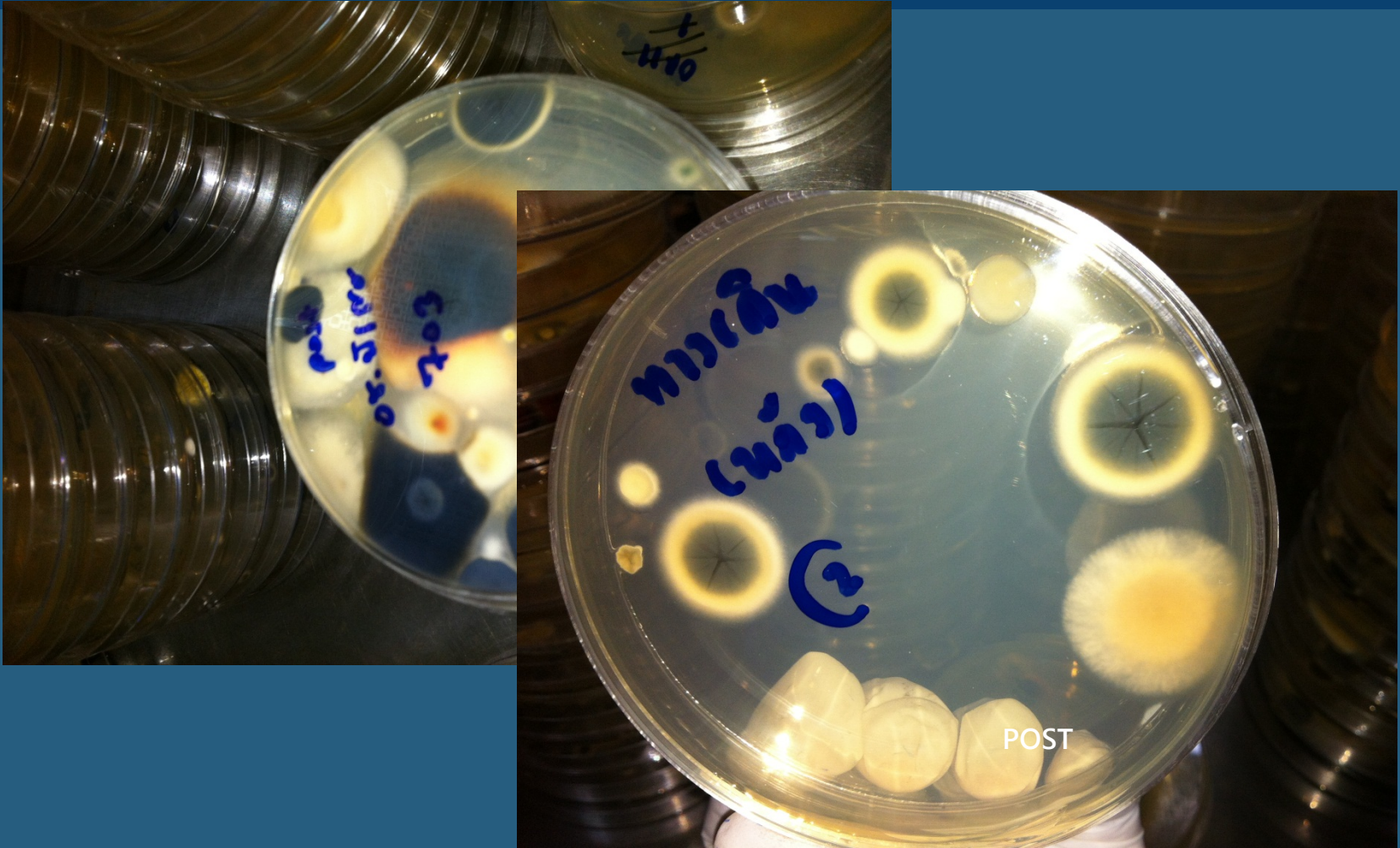
Outcomes (close units)



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

Outcomes (open units)



This finding is not surprising



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.

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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

Mem (13)
Vince (7)

NG
- uic NG
- system etc.

20 92 78 10 20 2.18
150 110 110 120 120 14.25
100 90 90 80 90 10.90





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

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

ห้องจุลชีววิทยา 02-9268802 / 02-9269460

: SPECIMEN: CSF (Cerebrospinal Fluid)

Aerobic Culture *

No Growth after 3 days

NO.: 8-0033

REPORTED BY ทนพญ.อนันตพร จันท์ฟอง / APPROVED BY ทนพญ.พน

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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	OB
Unit 1	No
Unit 2	No
Unit 3	No
Unit 4	No
Unit 5	Yes ^e
Unit 6	

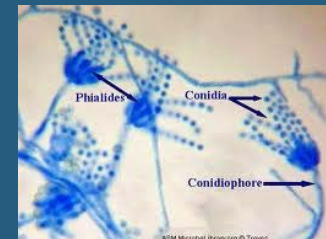
By multivariate analysis, initial fungal bioburden >500 CFU/m³ was associated with pseudo-outbreak due to moulds (aOR = 4.71; *P* =0.02)

Detection of Fungal in the Air by Non-standard Method



Predominant Fungus

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



Hospital Pre- Vs. Post-

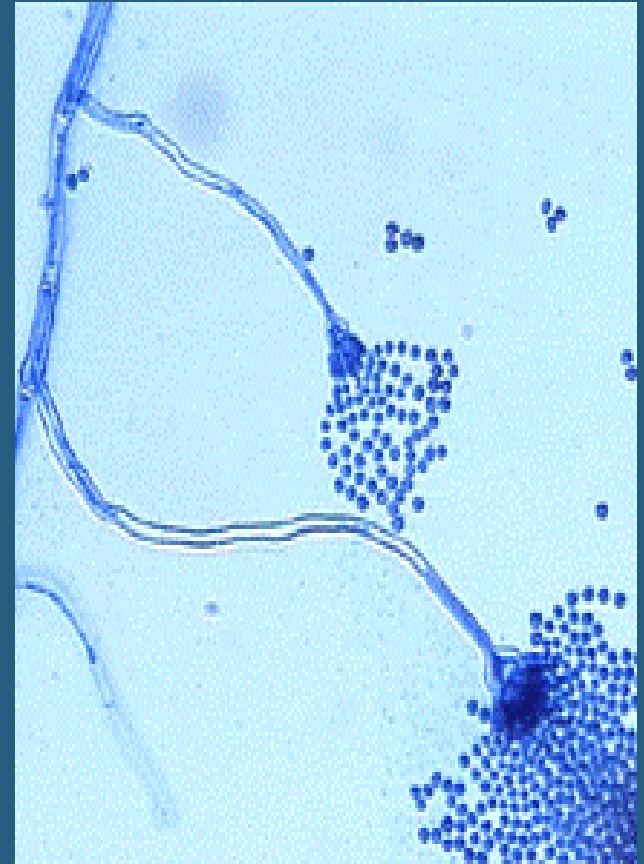


Initial Air Quality Check After Flood

Air quality characteristics	All rooms (N =68)	Open-ventilation patient care areas ¹	Closed-ventilation patient care areas ²	P Value
Relative humidity	<p>High bacterial and fungal bioburden >500 CFU/mm³ were detected only in units with excess humidity (100% vs. 0%; $P<0.001$)</p> <p>All areas with fungal pseudo-outbreak had excess humidity</p> <p>By multivariate analysis, first floor units were associated with excess fungal and bacterial bioburden (aOR = 1.16; $P<0.001$)</p>			
Temperature				
Care type				
Total fungal bioburden (CFU/m ³ , median, range) ³	590 (160-4,400)	775 (200-4,400)	430 (160-2680)	0.05

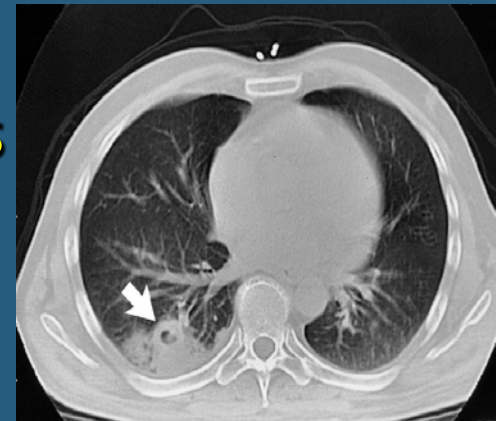
Invasive Infections: Aspergillus

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



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



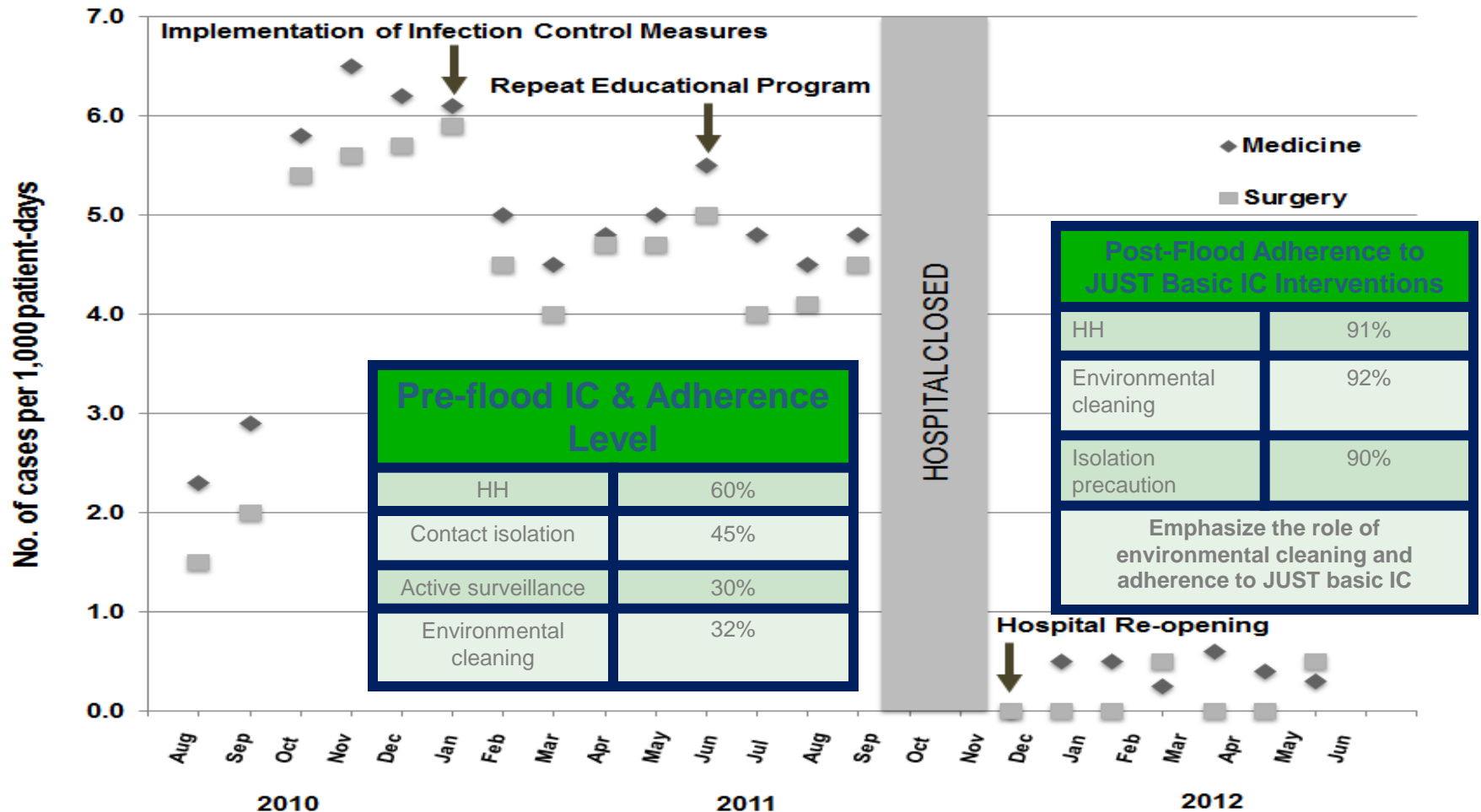
Surgical site infections and *Aspergillus spp.*

- 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

Healthcare Associated Infections After Flooding

Bacterial Infections

Termination of XDR-Acinetobacter: Lessons Learned

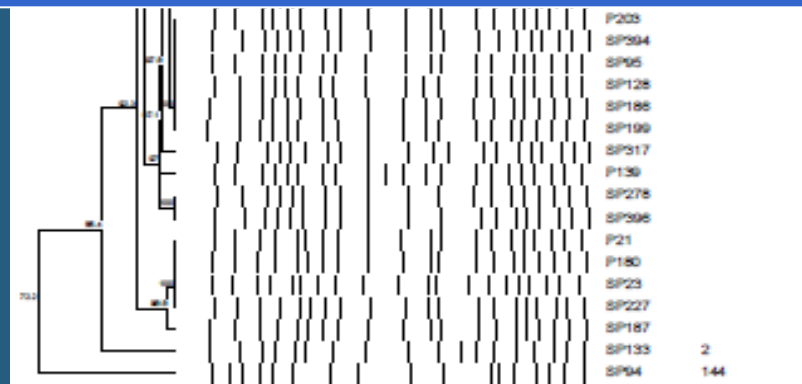


Control of *Acinetobacter* outbreak after floods

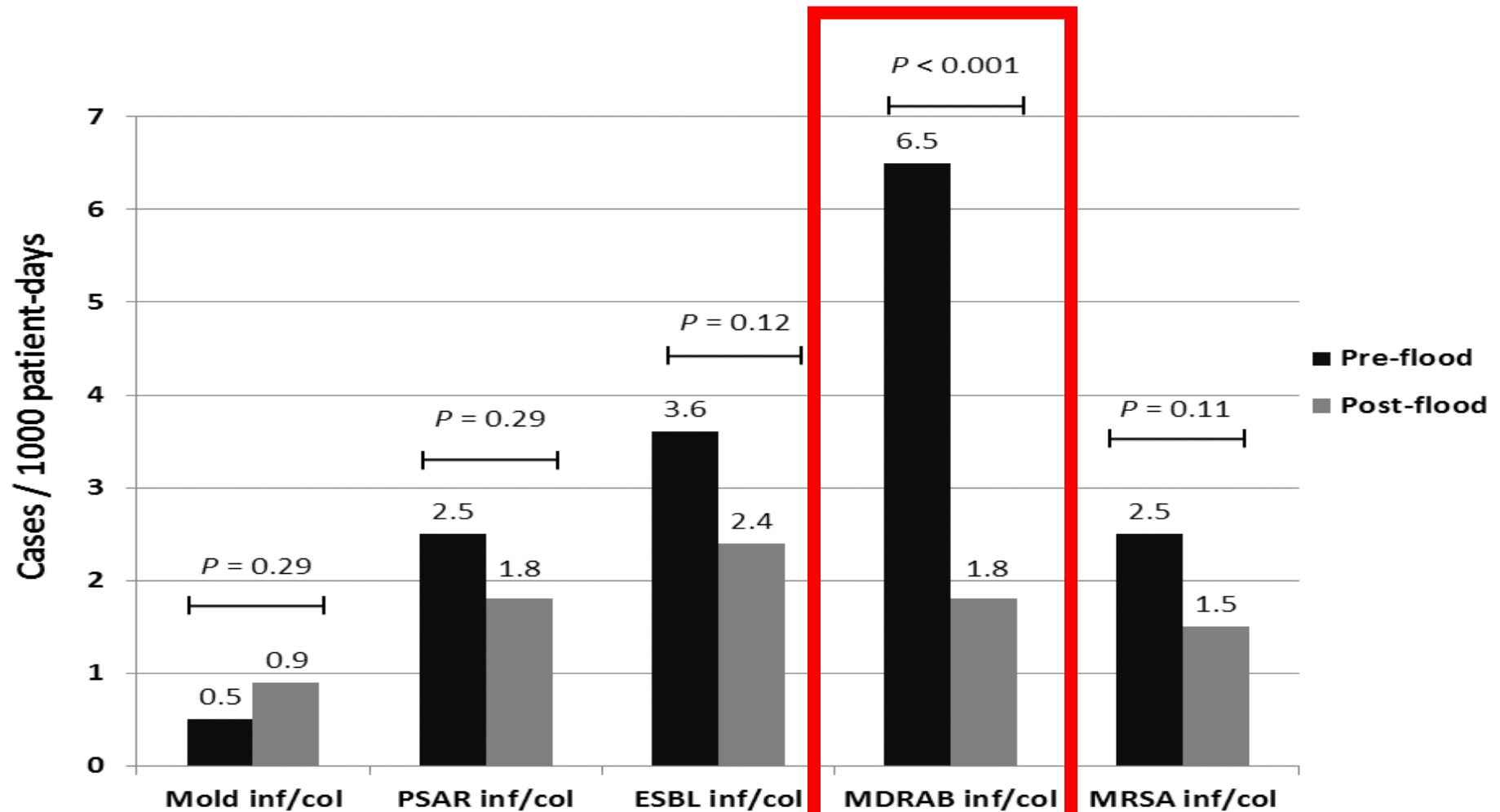


All except three belong to the same clone

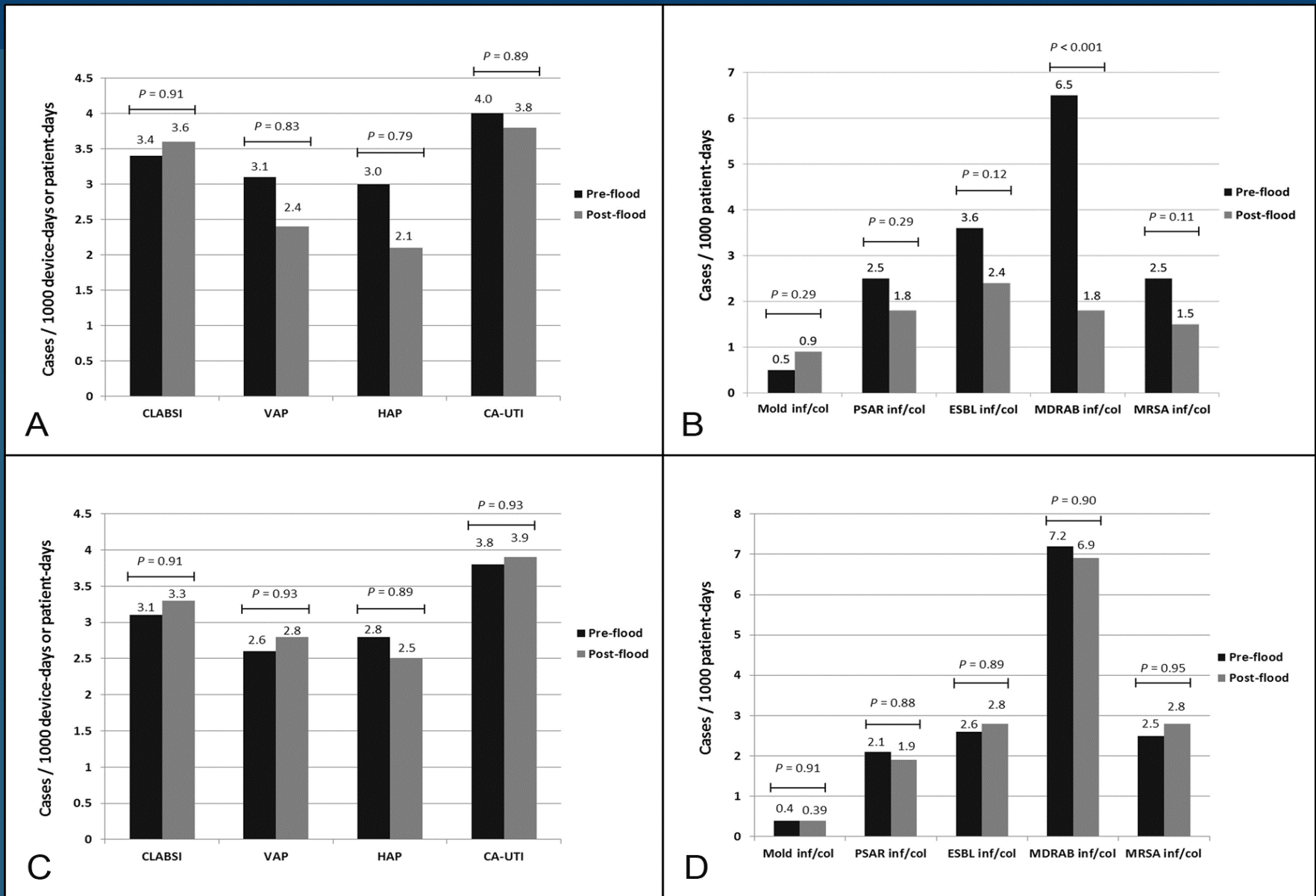
Courtesy of Dr. Hsu Li Yang



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



Nosocomial Infections Post-Flood



Surveillance After Flood

Traditional diseases:

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

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

Table 1

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

Case	Underlying conditions/diagnosis	<i>Burkholderia pseudomallei</i> 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

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

Surveillance for HCWs Health

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

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

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

Chronic asbestos exposure

Mesothelioma

Asbestosis

Need to monitor HCWs

Conclusions

Healthcare-associated infections and their prevention after extensive flooding

Anucha Apisarnthanarak^a, David K. Warren^b, and C. Glen Mayhall^c

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 thorough 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 ^{aa}]	Water borne enteric GNB (e.g., <i>Aeromonas</i> spp., <i>Vibrio</i> 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	
	<i>Legionella</i> 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
<i>Mycobacterium</i> spp. [25–29]	<i>Nontuberculous Mycobacterium</i> 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., <i>Aspergillus</i> spp., <i>Penicillium</i> spp., <i>Fusarium</i> 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

Reopening of Hospital Units After Flooding

HVAC and Air Sampling

- Frequent maintenance schedule for HVAC (e.g. air filter changes)
- Perform periodic air sampling to assess bioaerosol level, particularly in high risk units (e.g. transplantation unit)

Active and Laboratory-based Post-flood Surveillance

- For Gram-negative enteric bacteria, molds, mycobacteria and legionella
- Monitor for outbreaks/pseudo-outbreaks of flood related HAIs

Detection of Key Pathogens

Prompt Investigations

- Assess laboratory unit for contamination
- Assess CSSD unit for contamination
- Assess bacteria/fungal bioaerosol in affected units, if indicated
- Monitor basic infection control practices for procedures in affected units

Implementation of Infection Control Measures

- Appropriate cleaning and disinfection
- Periodic evaluation of performance and compliance
- Assess water quality, if indicated
- Consider using special area decontamination approaches (e.g., hydrogen peroxide vaporizer) in high risk units
- Repeat decontamination processes, if indicated

Thank you very much for
your attention

