From Plumbing to Patients: Outbreaks and Water Management Programs in Healthcare Settings

Matthew J. Arduino, MS, DrPH, FSHEA, M(ASCP)
Alicia Shugart, MA
Matthew J. Stuckey, PhD, MPH

Division of Healthcare Quality Promotion
National Center for Emerging and Zoonotic Infectious Diseases
Centers for Disease Control and Prevention
30 August 2022

The findings and conclusions in this presentation are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention

Use of trade names and commercial sources is for identification only and does not imply endorsement

Background

Outbreaks

Multidrug-Resistant Organisms

Water Management Programs

Recommendations and Resources

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Why Water Matters

- **Wet environments support microbial growth**
  - Source for antibiotic resistant pathogens and HAIs
- **Tap water meets stringent safety standards in the United States, but it is not sterile**
  - Rarely poses risk in community (e.g., for drinking, bathing, food prep)
- **In healthcare**
  - Vulnerable patient populations
  - Large, complex distribution systems
  - Water uses are varied, leading to unique exposure pathways
  - Building water quality often does not meet Safe Drinking Water Act (SDWA) standards

Water-Associated Pathogens

- Infections linked to potable water exposure
  - Direct and indirect
- Persistence in potable water and low nutrient environments
- Re-growth in potable water distribution systems
- Disinfection resistance/tolerance

Pseudomonas aeruginosa

Legionella pneumophila

- Falkinham III JO, Hilborn ED, Arduino MJ, Pruden A, Edwards MA. Epidemiology and ecology of opportunistic premise plumbing pathogens: *Legionella pneumophila*, *Mycobacterium avium*, and *Pseudomonas aeruginosa*. Environmental health perspectives. 2015;123(8).
- Williams MM, Armbruster CR, Arduino MJ. Plumbing of hospital premises is a reservoir for opportunistically pathogenic microorganisms: a review. Biofouling. 2013;29(2):147-62.

Water-Associated Pathogens

- Biofilm formation
- Thermal tolerance
- Resistance to phagocytosis by amoebae
- Survival and growth at low oxygen
- Slow growth

Water-Associated Pathogens

- Opportunistic pathogens are not contaminants of water
  - Environmental organisms
- Natural Microbiota of water, wet environments, and engineered water systems
- Organisms include gram-negative bacilli, gram-positive bacilli, fungi, and free-living amoeba
- Risk to general population generally low, though some special populations exist
  - Cystic Fibrosis, those with immune suppression
  - Those with pre-existing lung damage

Opportunistic Pathogens of Premise Plumbing

- *Legionella pneumophila*
- Non-fermenters: *Pseudomonas aeruginosa*, *P. fluorescens*, *P. putida*, *Achromobacter xylosoxidans*, *Acinetobacter baumannii* complex, *Burkholderia cepacia* complex, *Cupriavidus* spp., *Delftia* spp., *Elizabethkingia* spp., *Methylobacterium mesophilicum*, *Sphingomonas paucimobilis*, *Stenotrophomonas maltophilia*

Pseudomonas aeruginosa

Opportunistic Pathogens of Premise Plumbing

- Non-fecal coliforms: *Enterobacter*, *Klebsiella*, *Pantoea agglomerans* complex, *Serratia macescens*, *S. liquefaciens*
- Nontuberculous mycobacteria
- Fungi: *Aspergillus fumigatus*, *Fusarium*, *Phialemonium*

Aspergillus fumigatus

The 7 most reported water-associated healthcare acquired pathogens, CLABSI, VAP, CAUTI, SSI — NHSN, 2011–2014

Organism	Number of reports	%
Klebsiella pneumoniae/oxytoca	31,498	7.7
Pseudomonas aeruginosa	29,636	7.3
Enterobacter spp.	17,235	4.2
Yeast	10,811	2.6
Serratia spp.	5,463	1.3
Acinetobacter baumannii	4,375	1.1
Stenotrophomonas maltophilia	1,758	0.4

Why Water Matters in Healthcare

- **Patients may be vulnerable to infections from environmental organisms, which aren't typically a risk to the general population**
  - Drinking water exposures may be direct (e.g., infant formula) or indirect (e.g., patient care items/medications contaminated by sink splash)
- **Healthcare facilities have large, complex water distribution systems**
  - Environmental organisms are persistent, even in challenging growing conditions
  - Building water quality may not meet SDWA standards
- **It's not just *Legionella pneumophilia!***
  - Consider water-related exposures for a variety of organisms: Legionella, non-fermenters (e.g., *Pseudomonas* spp., *Serratia* spp.), non-fecal coliforms (e.g., *Enterobacter* spp., *Serratia* spp.), nontuberculous mycobacteria (NTMs), fungi, and amoeba

Notes from the Field: Mycobacterium abscessus Infections Among Patients of a Pediatric Dentistry Practice — Georgia, 2015

Weekly / April 8, 2016 / 65(13);355–356

Please note: *An erratum has been published for this report. To view the erratum, please click here.*

Gianna Peralta, MPH[1,2]; Melissa Tobin-D'Angelo, MD[1]; Angie Parham, DVM[1,3]; Laura Edison, DVM[1,4]; Lauren Lorentzson, MPH[1]; Carol Smith, MSHA[1]; Cherie Drenzek, DVM[1]

Plumbing of hospital premises is a reservoir for opportunistically pathogenic microorganisms: a review

Margaret M. Williams[a]*, Catherine R. Armbruster[b] and Matthew J. Arduino[a]

[a]*Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, GA, USA;* [b]*Department of*

Pseudomonas aeruginosa Outbreak in a Neonatal Intensive Care Unit Attributed to Hospital Tap Water

Cara Bicking Kinsey, PhD;[1] Samir Koirala, MBBS;[1] Benjamin Solomon, MD;[1] Jon Rosenberg, MD;[2] Byron F. Robinson, PhD;[1] Antonio Neri, MD;[1] Alison Laufer Halpin, PhD;[2] Matthew J. Arduino, DrPH;[3] Heather Moulton-Meissner, PhD;[3] Judith Noble-Wang, PhD;[3] Nora Chea, MD;[1,3] Carolyn V. Gould, MD[3]

OBJECTIVE. To investigate an outbreak of *Pseudomonas aeruginosa* infections and colonization in a neonatal intensive care unit.

DESIGN. Infection control assessment, environmental evaluation, and case-control study.

SETTING. Newly built community-based hospital, 28-bed neonatal intensive care unit.

PATIENTS. Neonatal intensive care unit patients receiving care between June 1, 2013, and September 30, 2014.

METHODS. Case finding was performed through microbiology record review. Infection control observations, interviews, and environmental assessment were performed. A matched case-control study was conducted to identify risk factors for *P. aeruginosa* infection. Patient and environmental isolates were collected for pulsed-field gel electrophoresis to determine strain relatedness.

RESULTS. In total, 31 cases were identified. Case clusters were temporally associated with absence of point-of-use filters on faucets in patient rooms. After adjusting for gestational age, case patients were more likely to have been in a room without a point-of-use filter (odds ratio [OR], 37.55; 95% confidence interval [CI], 7.16–∞). Case patients had higher odds of exposure to peripherally inserted central catheters (OR, 7.20; 95% CI, 1.75–37.30) and invasive ventilation (OR, 5.79; 95% CI, 1.39–30.62). Of 42 environmental samples, 28 (67%) grew *P. aeruginosa*. Isolates from the 2 most recent case patients were indistinguishable by pulsed-field gel electrophoresis from water-related samples obtained from these case-patient rooms.

CONCLUSIONS. This outbreak was attributed to contaminated water. Interruption of the outbreak with point-of-use filters provided a short-term solution; however, eradication of *P. aeruginosa* in water and fixtures was necessary to protect patients. This outbreak highlights the importance of understanding the risks of stagnant water in healthcare facilities.

Infect Control Hosp Epidemiol 2017;38:801–808

Outbreak of *Burkholderia cepacia* complex among ventilated pediatric patients linked to hospital sinks

Cynthia A. Lucero, MD,[a,b] Adam L. Cohen, MD, MPH,[a,b] Ingrid Trevino, DVM, MPH,[a,c] Angela Hammer Rupp, MT(ASCP), MS, CIC,[d] Michelle Harris, RN, MSN,[d] Sinead Forkan-Kelly, RN,[d] Judith Noble-Wang, PhD,[b] Bette Jensen, MMSc,[b] Alicia Sharni, MPH,[b] Matthew J. Arduino, MS, DrPH,[b] John J. LiPuma, MD,[e] Susan I. Gerber, MD,[f] and Arjun Srinivasan, MD[b]

Atlanta, Georgia; Ann Arbor, Michigan; and Chicago and Springfield, Illinois

We investigated a cluster of *Burkholderia cepacia* complex colonization in ventilated pediatric patients. Isolates from 15 patients, 2 sink drains, and several ventilator components were found to belong to a single *B cenocepacia* clone. Hospital tap water used during oral and tracheostomy care was identified as the most likely mechanism for transmission.

Key Words: Infection control; disease outbreak; intensive care unit; pediatrics; water supply; cystic fibrosis.

Background

Outbreaks

Multidrug-Resistant Organisms

Water Management Programs

Recommendations and Resources

Clinical Infectious Diseases

INVITED ARTICLE

IDSA Infectious Diseases Society of America · hivma hiv medicine association · OXFORD

HEALTHCARE EPIDEMIOLOGY: Robert A. Weinstein, Section Editor

Healthcare Outbreaks Associated With a Water Reservoir and Infection Prevention Strategies

Hajime Kanamori,[1,2] David J. Weber,[1,2] and William A. Rutala[1,2]

[1]Division of Infectious Diseases, University of North Carolina School of Medicine, ar

Hospital water may serve as a reservoir of healthcare-asso infections. The clinical features of waterborne outbreaks reviewed. The common waterborne pathogens were bacte culous mycobacteria, although fungi and viruses were occ ing bacteremia and invasive and disseminated diseases, well as neonates. Waterborne outbreaks occurred in heal tronic faucets (*Pseudomonas aeruginosa* and *Legionella*), in cardiac surgery (*Mycobacterium chimaera*). Advanced reservoirs and transmission pathways of waterborne path a practical approach for healthcare personnel.

Keywords. waterborne outbreaks; healthcare-associa

Table 2. Summary of Key Issues and Infection Prevention Strategies Against Waterborne Outbreaks by Major Water Reservoir in Healthcare Settings

Reservoir	Key Issues	Infection Prevention Strategies
Potable water, tap water, and hospital water systems	Potable water is not sterile, and pathogenic waterborne organisms may exist in potable water at acceptable levels of coliform bacteria (<1 coliform bacterium/100 mL). Healthcare-associated outbreaks have been linked to contaminated potable water. Semicritical devices are often rinsed with potable water, which may lead to contamination of the equipment and subsequent healthcare-associated infections. Common pathogens include nonenteric gram-negative bacilli (eg, *Pseudomonas aeruginosa*), *Legionella*, NTM.	Follow public health guidelines. Hot water temperature at the outlet at the highest temperature allowable, preferably >51°C. Water disruptions: post signs and do not drink tap water. Maintain standards for potable water (<1 coliform bacterium/100 mL). Rinse semicritical equipment with sterile water, filtered water, or tap water followed by alcohol rinse. Some experts have recommended periodic monitoring of water samples for growth of *Legionella*. *Legionella* eradication can be technically difficult, temporary, and expensive. Potential methods of eradication include filtration, ultraviolet, ozonization, heat inactivation (>60°C), hyperchlorination, and copper-silver ionization (>0.4 ppm and >0.04 ppm, respectively).
Sinks	Colonization of sinks with gram-negative bacilli has been reported. Some studies demonstrate a transmission link between a colonized sink and infected patients. Some studies describe that multidrug-resistant gram-negative bacilli are associated with contaminated sinks. Gram-negative bacilli can survive wet environments, including sinks, for a long time (>250 d) Transmission can be caused by splashing of water droplet from contaminated sinks to hands of healthcare personnel, followed by transient colonization of hands. Common pathogens include gram-negative bacilli (eg, *Pseudomonas*, *Acinetobacter*, *Serratia*).	Use separate sinks for handwashing and disposal of contaminated fluids. Decontaminate or eliminate sinks as a reservoir if epidemic spread of gram-negative bacteria via sinks is suspected.
Faucet aerators	Faucet aerators may serve as a platform for accumulation of waterborne pathogens. Potential pathogens include *Pseudomonas*, *Stenotrophomonas*, and *Legionella*.	Routine screening and disinfection or permanent removal of all aerators are not warranted at present. No precautions necessary at present. For *Legionella* outbreaks, clean and disinfect faucet aerators in

Clin Infect Dis. 2016
62(11):1423-35

California Healthline Daily Edition

Summaries of health policy coverage from major news organizations

2019

More Families Sue Dental Clinic Over Bacterial Infections Contracted Following Children's Root Canals

The bacterial outbreak, which occurred in 2016, sickened dozens of children, some of whom lost permanent teeth because of the infections. There are now 113 plaintiffs in a series of lawsuits against

4th patient with GHS infection dies

Liv Osby, losby@gannett.com Published 3:53 p.m. ET July 21, 2014 | Updated 6:59 p.m. ET July 21, 2014

The Post and Courier

FOUNDED 1803 WINNER OF THE PULITZER PRIZE

65° SUNNY

ALL SECTIONS E-EDITION OBITUARIES BUY & SELL CUSTOMER SERVICE SUBSCRIBE

SPECIAL COVERAGE A secret. A search warrant. A veteran. A trap: How 7 SC officers fell in Florence

Dozens of Roper Hospital patients developed waterborne bacterial infection after surgery

BY LAUREN SAUSSER LSAUSSER@POSTANDCOURIER.COM

APR 13, 2018

ContagionLive Infectious Diseases Today

Get the content you want anytime yo

NEWS CONFERENCES OUTBRE

<< View All Contributors

Saskia v. Popescu

Saskia v. Popescu, MPH, MA, CIC, is a hospital epidemiologist and infec preventionist with Phoenix Children's Hospital. During her work as an infe preventionist she performed surveillance for infectious diseases, preparedness, and Ebola-response practices. She is currently a PhD candidate in Biodefense at George Mason University where her research focuses on the role of infection prevention in facilitating global health security efforts. She is certified in Infection Control.

Investigating an *Elizabethkingia anophelis* Cluster in a Pediatric ICU

AUG 24, 2018 | SASKIA V. POPESCU

Intensive care units (ICUs) are the last place infection preventionists want to see an outbreak. There is no "good" location for an outbreak, but an ICU is perhaps one of the worst, as the sickest, most vulnerable patients are cared for in such units. Like an oncology unit, an ICU experiencing cases of infection with an unusual organism can represent a canary in the coal mine.

Elizabethkingia bacteria are found in soil, river water, and reservoirs; however, they tend to only cause disease for those with weakened immune systems. The most common manifestations are meningitis and respiratory infections.

SECTIONS SEARCH THE BALTIMORE SUN SUBSCRIBE 4 weeks for 99¢ LOG IN

WEDNESDAY APR. 17, 2019 LATEST ENEWSPAPER ASK US POPULAR MD POLITICS SPORTS OBITS ADVERTISING 57°

ADVERTISEMENT

Health / Picture of Health

Bacterial outbreak closes Prince George's hospital neonatal intensive care unit

Infection Control & Hospital Epidemiology (2019), 1–6
doi:10.1017/ice.2019.60

Original Article

Investigation of healthcare infection risks from water-related organisms: Summary of CDC consultations, 2014—2017

Kiran M. Perkins MD, MPH, Sujan C. Reddy MD, Ryan Fagan MD, MPH, Matthew J. Arduino MS, DrPH and Joseph F. Perz DrPH, MA

Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia

Abstract

Objective: Water exposures in healthcare settings and during healthcare delivery can place patients at risk for infection with water-related organisms and can potentially lead to outbreaks. We aimed to describe Centers for Disease Control and Prevention (CDC) consultations involving water-related organisms leading to healthcare-associated infections (HAIs).

Design: Retrospective observational study.

Methods: We reviewed internal CDC records from January 1, 2014, through December 31, 2017, using water-related terms and organisms, excluding *Legionella*, to identify consultations that involved potential or confirmed transmission of water-related organisms in healthcare. We determined plausible exposure pathways and routes of transmission when possible.

Results: Of 620 consultations during the study period, we identified 134 consultations (21.6%), with 1,380 patients, that involved the investigation of potential water-related HAIs or infection control lapses with the potential for water-related HAIs. Nontuberculous mycobacteria were involved in the greatest number of investigations (n = 40, 29.9%). Most frequently, investigations involved medical products (n = 48, 35.8%), and most of these products were medical devices (n = 40, 83.3%). We identified a variety of plausible water-exposure pathways, including medication preparation near water splash zones and water contamination at the manufacturing sites of medications and medical devices.

Conclusions: Water-related investigations represent a substantial proportion of CDC HAI consultations and likely represent only a fraction of all water-related HAI investigations and outbreaks occurring in US healthcare facilities. Water-related HAI investigations should consider all potential pathways of water exposure. Finally, healthcare facilities should develop and implement water management programs to limit the growth and spread of water-related organisms.

22% (134) of CDC Consultations Were Water-Related

- 40 (30%) involved NTMs
- 45 (35%) involved MDROs
- 24 (18%) surgery-related
- 40 (30%) involved medical devices
- 13 (10%) involved medication contamination

Perkins et al. Investigation of healthcare infection risks from water-related organisms: Summary of CDC consultations, 2014-2017. Infect Control Hosp Epidemiol 2019; 40(6):621-626.

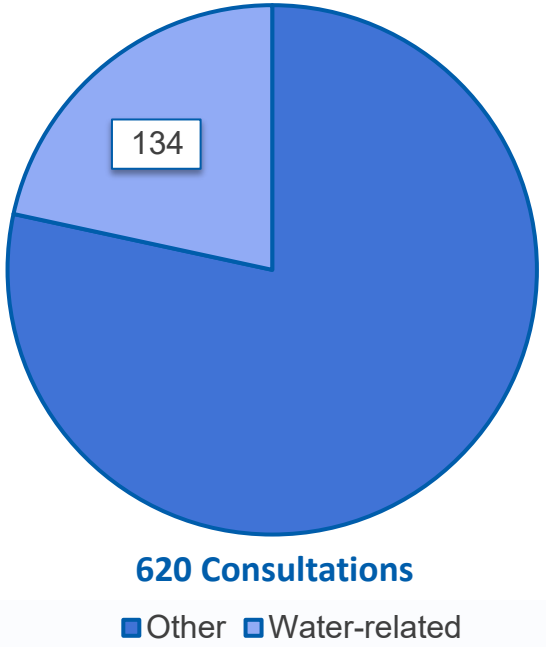


Table 3. Possible Exposure Pathways and Routes of Transmission Involved in Water-Related Investigations, Division of Healthcare Quality Promotion, CDC, United States, 2014–2017

Injection/medication preparation near sink[a]
Nutrition (including breast milk and infant formula) preparation near sink[a]
Patient care supplies stored by sinks and toilets in intensive care unit[a]
Contaminated compounded nasal spray used prior to laryngoscopy
Contaminated water from neonatal intensive care unit (NICU) sinks[a]
Contaminated water from operating room scrub sinks[a]
Contaminated sink drains[a]
Contaminated dialysis wall boxes[a]
Use of nonsterile ice for patient care among immunocompromised patients[a]
Use of contaminated water in dental water lines[10,11,a]
Water introduction during respiratory therapy[a]
Use of tap water during bronchoscopy procedures[a]
Use of nonsterile water for humidification reservoirs of infant incubators in NICU[a]
Use of consumer-grade humidifier in operating room during LASIK procedures[12]
Use of nonsterile water and inadequate disinfection of heater-cooler devices used during cardiac surgery[13–15,a]
Intrinsic contamination of medical products due to water contamination at production site[16,17,a]
Poor medical device reprocessing procedures[a]
Contaminated automated endoscope reprocessors
Poor cleaning and disinfection of hydrotherapy rooms and equipment[a]
Water from contaminated shower heads[a]
Improperly cleaned mobile shower trolleys
Hot tub use by surgical personnel[a]
Water contamination of specimens/reagents in the laboratory[a]
Building water leaks in patient care areas

[a]Indicates a potential exposure pathway or route of transmission that was documented as the possible source of infection in two or more investigations.

Outbreaks Linked to Manufacturing of Medical Devices

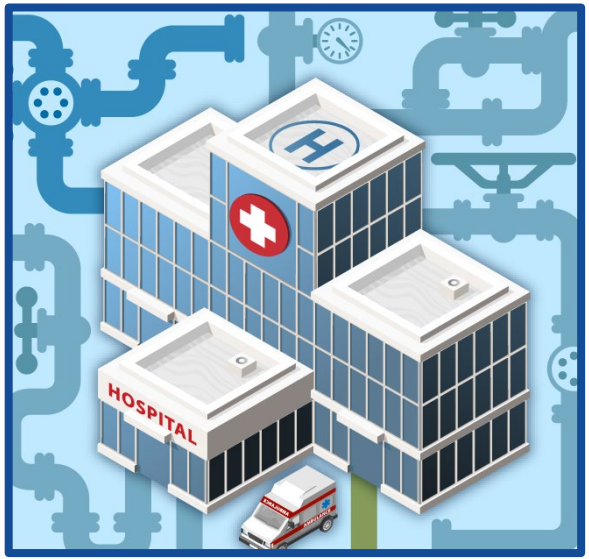
- LivaNova 3T heater-cooler
  - http://doi.org/10.2807/1560-7917.ES.2016.21.17.30215
- Respiratory therapy device
  - https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5441a5.htm
- CapnoProbes
  - https://www.cdc.gov/mmwr/preview/mmwrhtml/mm53d827a1.htm

Recent Outbreaks in Healthcare Settings

- **Neonatal Intensive Care Units (NICU)**
  - *Pseudomonas aeruginosa* infections among neonates contamination of breast milk, MD
- **Long-term Acute Care Hospitals (LTACH)**
  - *Elizabethkingia menigosepticum* and *E. anopheles* associated with showering (mechanically ventilated patients, handling of nebulizers, etc.), AZ, CA, KY, IL (2017–2019)

Recent Outbreaks in Healthcare Settings

- **Tertiary Care Hospitals**
  - *Mycobacterium abscessus* infections associated with use of ice (2018)
- **Dental Clinics**
  - *Mycobacterium abscessus* infection in a pediatric pulpotomey patient, CA (2018)
  - *Mycobacterium abscessus* infections in pediatric pulpotomy patients, GA, CA (2016)



Surgical Personnel “Tubbing” Before Work

- Surgical site infections; pace-maker pocket infections, infections following orthopedic and cosmetic surgery (*M. abscessus*, *M. goodii*, *M. jaccuzzii*, *M. wolynskii*)

  - Scheflan M, Wixtrom RN. **Over Troubled Water: An Outbreak of Infection Due to a New Species of Mycobacterium following Implant-Based Breast Surgery.** *Plast Reconstr Surg* 2016;137(1):97-105
  - Rahav G, et al. **An outbreak of *Mycobacterium jacuzzii* infection following insertion of breast implants.** *Clin Infect Dis*. 2006;43(7):823-30.

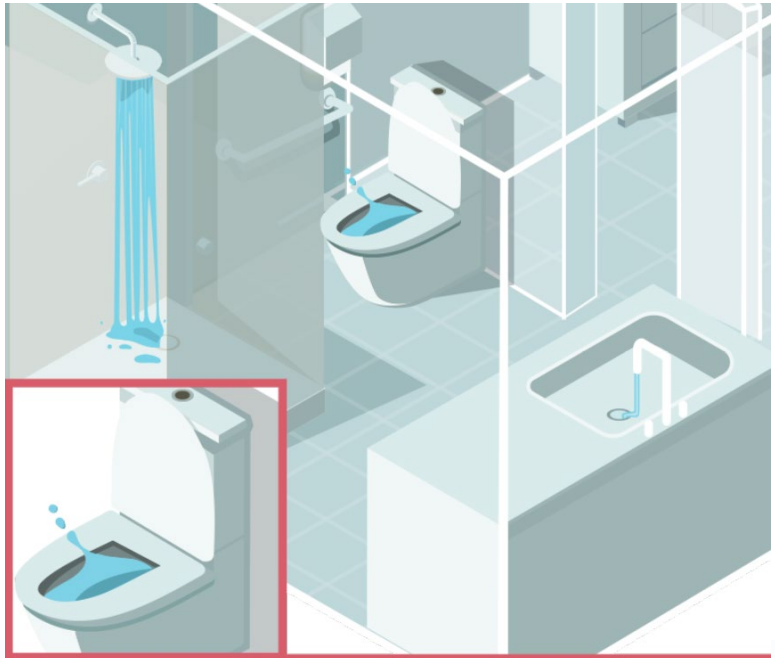
Sources Identified During Outbreaks

- Contamination of total parenteral nutrition solution (TPC)
  - Rinsing mixing tank with tap water and failure of filter to remove ultra-microcells
- Contamination of healthcare workers
- Contamination of injectable medication prepared by sinks

Sources Identified During Outbreaks

- Contamination of healthcare worker hands during handwashing
- Use of residential humidifier in OR filled with tap water
- Use of house ice
- Splash from sink and drains
- Reprocessing medical device or using tap water to fill water reservoirs

Toilets and Hoppers



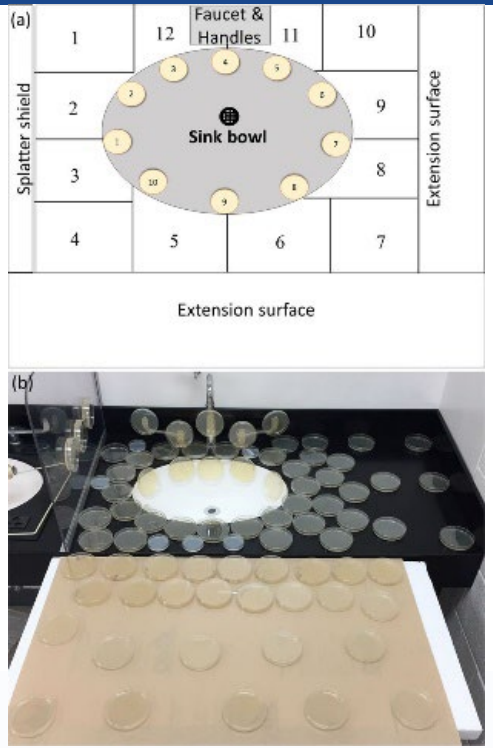
Water droplets and aerosolization from contaminated shower heads and toilets

- **Flushing create plumes and aerosols and leads to environmental contamination**
- **Separate room with a door and lids**

  - Aithinne KAN, et al. **Toilet plume aerosol generation rate and environmental contamination following bowl water inoculation with *Clostridium difficile* spores.** *Am J Infect Control* 2019;47(5):515-520.
  - Barker J, Jones MV. **The potential spread of infection caused by aerosol contamination of surfaces after flushing a domestic toilet.** *J Appl Microbiol.* 2005;99(2):339-47.
  - Best EL, Sandoe JA, Wilcox MH. **Potential for aerosolization of *Clostridium difficile* after flushing toilets: the role of toilet lids in reducing environmental contamination risk.** *J Hosp Infect*. 2012;80(1):1-5
  - Gerba CP, Wallis C, Melnick JL. **Microbiological hazards of household toilets: droplet production and the fate of residual organisms.** *Appl Microbiol.* 1975 Aug;30(2):229-37.
  - Sassi HP, Reynolds KA, Pepper IL, Gerba CP. **Evaluation of hospital-grade disinfectants on viral deposition on surfaces after toilet flushing.** *Am J Infect Control.* 2018;46(5):507-511.
  - Wilson GM, et al. **Bioaerosols generated from toilet flushing in rooms of patients with *Clostridioides difficile* infection.** *Infect Control Hosp Epidemiol.* 2020;41(5):517-521.

Wastewater Sources

- Biofilms in p-traps and sink contamination
- May include waterborne and non-waterborne pathogens
- Use of hoppers in patient rooms without covers/lids
- Contamination of toilet drain wastewater (retrograde growth from sanitary plumbing)
  - Hayward C, Brown MH, Whiley H. Hospital water as the source of healthcare-associated infection and antimicrobial resistant pathogens. *Curr Opinion Infect Dis* 2022; 35:339–345
  - Heireman L, et al. **Toilet drain water as a potential source of hospital room-to-room transmission of carbapenemase-producing *Klebsiella pneumoniae*.** *J Hosp Infect*. 2020t;106(2):232-239
  - Park SC, et al. **Risk Factors Associated with Carbapenemase-Producing Enterobacterales (CPE) Positivity in the Hospital Wastewater Environment.** *Appl Environ Microbiol*. 2020;86(24):e01715-20.



Kotay S, et al. *Appl Environ Microbiol* 2017;83 (8):e03327-16

Green Buildings and Heater-Cooler Devices

- New green building on campus
- 36/71 lung transplant patients involved
- 12/24 cardiac surgery patients
- *M. abscessus* present in water from taps and in ice
- Drinking water used to fill heater-cooler units
- Lung transplant patients placed on a sterile water protocol

Clinical Infectious Diseases

MAJOR ARTICLE

IDSA Infectious Diseases Society of America | hivma hiv medicine association | OXFORD

Two-Phase Hospital-Associated Outbreak of *Mycobacterium abscessus*: Investigation and Mitigation

Arthur W. Baker,[1,2] Sarah S. Lewis,[1,2] Barbara D. Alexander,[2,3] Luke F. Chen,[1,2] Richard J. Wallace Jr,[4] Barbara A. Brown-Elliott,[4] Pamela J. Isaacs,[1] Lisa C. Pickett,[5] Chetan B. Patel,[6] Peter K. Smith,[7] John M. Reynolds,[8] Jill Engel,[3] Cameron R. Wolfe,[2] Carmelo A. Milano,[7] Jacob N. Schroder,[7] Robert D. Davis,[7] Matthew G. Hartwig,[7] Jason E. Stout,[2] Nancy Strittholt,[1] Eileen K. Maziarz,[2] Jennifer Horan Saullo,[2] Kevin C. Hazen,[3] Richard J. Walczak Jr,[10] Ravikiran Vasireddy,[4] Sruthi Vasireddy,[4] Celeste M. McKnight,[3] Deverick J. Anderson,[1,2] and Daniel J. Sexton[1,2]

[1]Duke Program for Infection Prevention and Healthcare Epidemiology and [2]Division of Infectious Diseases, Duke University Hospital, and [3]Duke University Clinical Microbiology Laboratory, Durham, North Carolina; [4]Mycobacteria/Nocardia Research Laboratory, Department of Microbiology, University of Texas Health Science Center, Tyler; and Divisions of [5]Trauma and Critical Care, [6]Cardiology, [7]Cardiovascular and Thoracic Surgery, and [8]Pulmonary, Allergy, and Critical Care Medicine, [9]Duke University Hospital, and [10]Perfusion Services, Duke University Hospital, Durham, North Carolina

(See the Editorial Commentary by Crist and Perz on pages 912-3.)

Background. Nontuberculous mycobacteria (NTM) commonly colonize municipal water supplies and cause healthcare-associated outbreaks. We investigated a biphasic outbreak of *Mycobacterium abscessus* at a tertiary care hospital.

Methods. Case patients had recent hospital exposure and laboratory-confirmed colonization or infection with *M. abscessus* from January 2013 through December 2015. We conducted a multidisciplinary epidemiologic, field, and laboratory investigation.

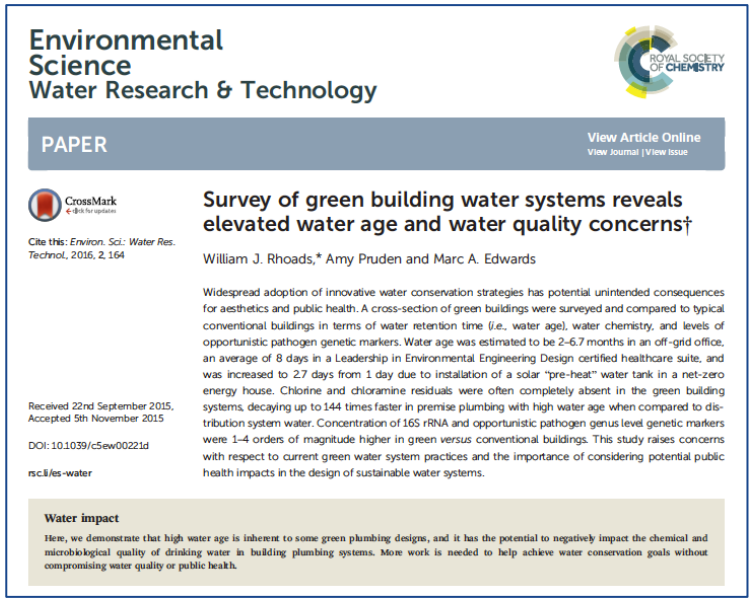
Results. The incidence rate of *M. abscessus* increased from 0.7 cases per 10 000 patient-days during the baseline period (January 2013–July 2013) to 3.0 cases per 10 000 patient-days during phase 1 of the outbreak (August 2013–May 2014) (incidence rate ratio, 4.6 [95% confidence interval, 2.3–8.8]; $P < .001$). Thirty-six of 71 (51%) phase 1 cases were lung transplant patients with positive respiratory cultures. We eliminated tap water exposure to the aerodigestive tract among high-risk patients, and the incidence rate decreased to baseline. Twelve of 24 (50%) phase 2 (December 2014–June 2015) cases occurred in cardiac surgery patients with invasive infections. Phase 2 resolved after we implemented an intensified disinfection protocol and used sterile water for heater-cooler units of cardiopulmonary bypass machines. Molecular fingerprinting of clinical isolates identified 2 clonal strains of *M. abscessus*; 1 clone was isolated from water sources at a new hospital addition. We made several water engineering interventions to improve water flow and increase disinfectant levels.

Conclusions. We investigated and mitigated a 2-phase clonal outbreak of *M. abscessus* linked to hospital tap water. Healthcare facilities with endemic NTM should consider similar tap water avoidance and engineering strategies to decrease risk of NTM infection.

Keywords. hospital outbreak; nontuberculous mycobacteria; *Mycobacterium abscessus*; infection control; hospital water safety.

What Happens with Green Buildings?

- Water efficiency e.g., low flow toilets and fixtures
- Increased water age (2–6.7 months, average 8 days in a LEED certified healthcare suite)
- No disinfectant residual
- Increased use of plastic plumbing materials for water distribution
  - Rhoads WJ, Pruden A, Edwards MA. Survey of green building water systems reveals elevated water age and water quality concerns. *Environ Sci: Water Res Technol* 2016; 2: 164–173



Environmental Science
Water Research & Technology

PAPER

View Article Online
View Journal | View Issue

CrossMark

Cite this: *Environ. Sci.: Water Res. Technol.*, 2016, 2, 164

Survey of green building water systems reveals elevated water age and water quality concerns†

William J. Rhoads,* Amy Pruden and Marc A. Edwards

Widespread adoption of innovative water conservation strategies has potential unintended consequences for aesthetics and public health. A cross-section of green buildings were surveyed and compared to typical conventional buildings in terms of water retention time (*i.e.*, water age), water chemistry, and levels of opportunistic pathogen genetic markers. Water age was estimated to be 2–6.7 months in an off-grid office, an average of 8 days in a Leadership in Environmental Engineering Design certified healthcare suite, and was increased to 27 days from 1 day due to installation of a solar "pre-heat" water tank in a net-zero energy house. Chlorine and chloramine residuals were often completely absent in the green building systems, decaying up to 144 times faster in premise plumbing with high water age when compared to distribution system water. Concentration of 16S rRNA and opportunistic pathogen genus level genetic markers were 1–4 orders of magnitude higher in green *versus* conventional buildings. This study raises concerns with respect to current green water system practices and the importance of considering potential public health impacts in the design of sustainable water systems.

Received 22nd September 2015,
Accepted 5th November 2015

DOI: 10.1039/c5ew00221d

rsc.li/es-water

Water impact

Here, we demonstrate that high water age is inherent to some green plumbing designs, and it has the potential to negatively impact the chemical and microbiological quality of drinking water in building plumbing systems. More work is needed to help achieve water conservation goals without compromising water quality or public health.

What Happens with Green Buildings?

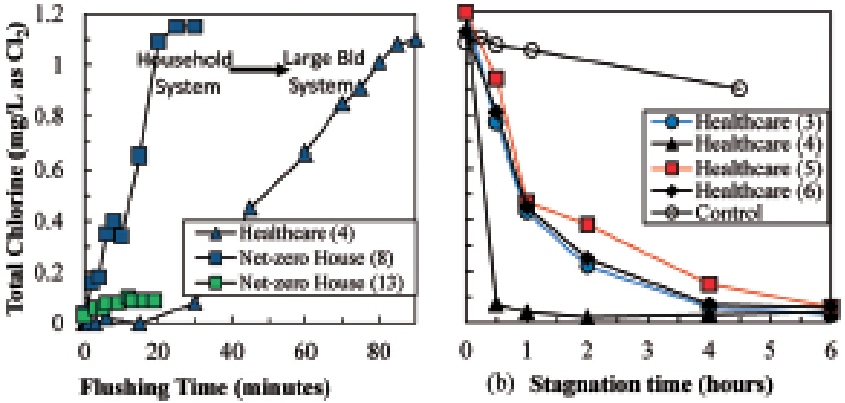
Table 1 Summary of key factors regarding water age in three field sites and a baseline comparison

Parameter		Healthcare suite	Net-zero energy house	Net-zero office	Conventional home
Building type		10 000 sqft LEED-Gold outpatient healthcare facility	Net-zero energy single family household	Small net-zero water and net-zero energy office	Conventional household, no green features
Total storage volume		80 gallon water heater	160 gallons hot water due to solar water heater	3000 gallon rainwater cistern	80 gallons hot water
Approximate demand		2627 gallons in 2013 (7.2 gallons per day on average)	26 000 gallons per year (65–80 gallons per day)	5000–8000 gallons per year[a]	110 000 gallons per year[b] (>300 gallons per day)
Water age estimate		8 days on average	Hydraulic retention time = 2.7 days in hot water storage tanks; higher in infrequently used lines	1–6 months, dependent on rainfall and use	Hydraulic retention time ~1 day in water heater
Water system		Cold line: plug flow hot lines: continuous recirculation	Plug flow	Continuously mixed, air–water interface storage	Plug flow
Disinfectant Residual		Chloramine	Chlorine	N/A	Chlorine
Primary Plumbing Material		Copper	Copper to manifold; PEX after manifold	Copper	Copper
In-building treatment		N/A	N/A	20 μm + 5 μm + GAC filter + UV inactivation	N/A
Residual (as Cl_2) 1st draw	Cold	0.01–0.04 mg L^{-1}	0.04 mg L^{-1}	N/A	0.71 mg L^{-1}
	Hot	0.0–0.03 mg L^{-1}	0.02 mg L^{-1}	N/A	0.06 mg L^{-1}
Residual (as Cl_2) flushed	Cold	<0.25 mg L^{-1} 3 min; 1.12 mg L^{-1} 80 min	0.17 mg L^{-1} 3 min; 1.15 mg L^{-1} 30 min	N/A	1.04 mg L^{-1} 3 min
	Hot	0.02–0.03 mg L^{-1} 3 min	0.41 mg L^{-1} 5 min; 0.96 mg L^{-1} 50 min	N/A	0.06 mg L^{-1} 3 min
Cause of high water age		Long service pipe within building, high number of fixtures, infrequent use	Solar water heater with storage to pre-heat water before heat pump	Storage in cistern necessary, water age dependent on rainfall, use, and maintenance	Normal water age

[a] Estimated based on discussions with employees and observations made in the field. [b] Average annual use for American families.

Rhoads WJ, Pruden A, Edwards MA. Survey of green building water systems reveals elevated water age and water quality concerns. *Environ Sci: Water Res Technol* 2016; 2: 164–173

What Happens with Green Buildings



Note: Sampling locations indicated in parenthesis in the figure legends correspond to sample locations depicted in Figure 1.

Fig. 2 Total chlorine residual concentrations (a) as a function of stagnation in one room at the healthcare suite (large building system above), a tap near the head of the building at the net-zero house (household system above), and during three showering events at net-zero house, and (b) as a function of stagnation in several rooms at FS#1 (control represents identical water placed in a glass container with no head space).

Rhoads WJ, Pruden A, Edwards MA. Survey of green building water systems reveals elevated water age and water quality concerns. *Environ Sci: Water Res Technol* 2016;2:164–173

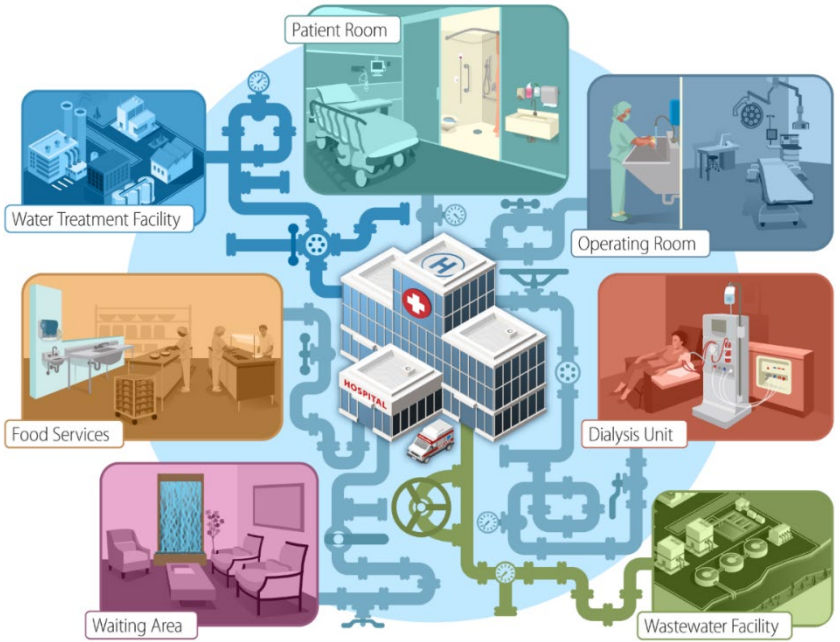
Potential Transmission Routes from Water to Patients

- Improperly reprocessing medical devices
- Using poor quality water for immunocompromised patients
- Using poor quality water in NICU infant incubators
- Preparing nutrition (e.g., infant formula) near a sink
- Preparing injections and medications near sinks
- Improper tap water use in respiratory care
- Improper oral care in immunocompromised patients
- Water droplets and aerosolization from contaminated shower heads and toilets
- Splashes from sink drains

https://www.cdc.gov/hai/images/Potential-Transmission-Routes-from-Water-to-Patients.jpg

Water-related Outbreaks: Summary

- Water-related outbreaks are common
- There are many possible sources of exposure across a facility, but immuno-compromised and ICU patients are at increased risk
- Green buildings can increase the risk of water-related outbreaks



Background

Outbreaks

Multidrug-Resistant Organisms

Water Management Programs

Recommendations and Resources

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Urgent Multidrug-Resistant Organisms (MDROs)

- Many MDRO outbreaks have been linked to premise plumbing, including urgent public health threats
  - e.g., Carbapenem-resistant organisms

https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf

Urgent Threats

- Carbapenem-resistant *Acinetobacter*
- *Candida auris*
- *Clostridioides difficile*
- Carbapenem-resistant Enterobacteriaceae
- Drug-resistant *Neisseria gonorrhoeae*

Serious Threats

- Drug-resistant *Campylobacter*
- Drug-resistant *Candida*
- ESBL-producing Enterobacteriaceae
- Vancomycin-resistant *Enterococci*
- Multidrug-resistant *Pseudomonas aeruginosa*
- Drug-resistant nontyphoidal *Salmonella*
- Drug-resistant *Salmonella* serotype Typhi
- Drug-resistant *Shigella*
- Methicillin-resistant *Staphylococcus aureus*
- Drug-resistant *Streptococcus pneumoniae*
- Drug-resistant Tuberculosis

Concerning Threats

- Erythromycin-resistant group A *Streptococcus*
- Clindamycin-resistant group B *Streptococcus*

Emerging MDROs: Carbapenem-Resistant Organisms

Clinical Infectious Diseases

REVIEW ARTICLE

The Hospital Water Environment as a Reservoir for Carbapenem-Resistant Organisms Causing Hospital-Acquired Infections—A Systematic Review of the Literature

Alice E. Kizny Gordon,[1] Amy J. Mathers,[3] Elaine Y. L. Cheong,[4,5] Thomas Gottlieb,[4,5] Shireen Kotay,[3] A. Sarah Walker,[1,2] Timothy E. A. Peto,[1,2] Derrick W. Crook[1,2] and Nicole Stoesser[1]

[1]Modernising Medical Microbiology Consortium, Nuffield Department of Medicine, John Radcliffe Hospital, University of Oxford, and [2]Oxford Biomedical Research Centre, United Kingdom; [3]Division of Infectious Diseases and International Health, Department of Medicine, University of Virginia Health System, Charlottesville; [4]Department of Microbiology & Infectious Diseases, Concord Repatriation Hospital, Sydney, and [5]University of Sydney, Australia

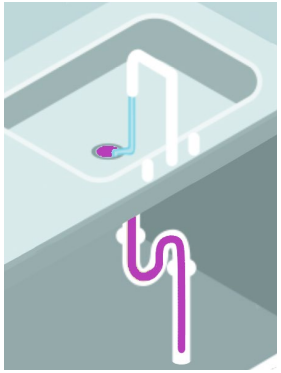
Over the last 20 years there have been 32 reports of carbapenem-resistant organisms in the hospital water environment, with half of these occurring since 2010. The majority of these reports have described associated clinical outbreaks in the intensive care setting, affecting the critically ill and the immunocompromised. Drains, sinks, and faucets were most frequently colonized, and *Pseudomonas aeruginosa* the predominant organism. Imipenemase (IMP), *Klebsiella pneumoniae* carbapenemase (KPC), and Verona integron-encoded metallo-β-lactamase (VIM) were the most common carbapenemases found. Molecular typing was performed in almost all studies, with pulse field gel electrophoresis being most commonly used. Seventy-two percent of studies reported controlling outbreaks, of which just more than one-third eliminated the organism from the water environment. A combination of interventions seems to be most successful, including reinforcement of general infection control measures, alongside chemical disinfection. The most appropriate disinfection method remains unclear, however, and it is likely that replacement of colonized water reservoirs may be required for long-term clearance.

Keywords. carbapenem-resistant; carbapenemase; healthcare-associated infections; outbreak; water.

Clin Infect Dis. 2017. doi: 10.1093/cid/cix132

- 32 reports of carbapenem-resistant organisms in hospital water environment
  - Most common organism: *Pseudomonas* spp.
  - Most common carbapenemases: VIM, IMP, KPC.
- Most in the ICU, affecting the critically ill and the immunocompromised
- Drains, sinks, and faucets were most frequently colonized
- A combination of interventions was most successful for controlling outbreaks

MDROs & Premise Plumbing



- Sinks, toilets, and hoppers can become contaminated with MDROs
  - Pathogens stick to pipes and form biofilms
  - Organisms can persist for long periods of time in biofilms
  - Biofilms are often impossible to fully remove
- Different bacterial species may contaminate the same drain and transfer their antimicrobial resistance genes to other bacterial species
- In 2020, Ecolab Inc.'s disinfectant Virasept™ was the first product to receive EPA approval for disinfection of biofilms in wastewater drains.
  - When applied with a foamer, Virasept™ is EPA registered to kill *Pseudomonas aeruginosa* and *Staphylococcus aureus* biofilms in drains with a 5-minute contact time.

    https://www.ecolab.com/offerings/ready-to-use-disinfectants/virasept

MDRO Exposures

- Patients may be exposed to organisms in drains when water splashes from the drain into the surrounding area
  - Splashes may occur when water flow hits the contaminated drain cover or when a toilet or hopper is flushed
  - Splashes can disseminate MDRO-containing droplets, which can contaminate the local environment or the skin of nearby healthcare personnel and patients

Multidrug-Resistant Organisms: Summary

- Premise plumbing can provide an environment for antimicrobial resistant organisms to share their genes
- Patients may be exposed when water from sink drains, toilets, or hoppers, disperse MDRO-containing droplets into the environment, contaminating counters, clean supplies, medications, etc. within the splash zone
  - Consider checking for sink clutter as part of IPC rounds
- Outbreaks of MDROs related to premise plumbing are common, including some emerging antibiotic resistance that requires an aggressive public health response

Background

Outbreaks

Multidrug-Resistant Organisms

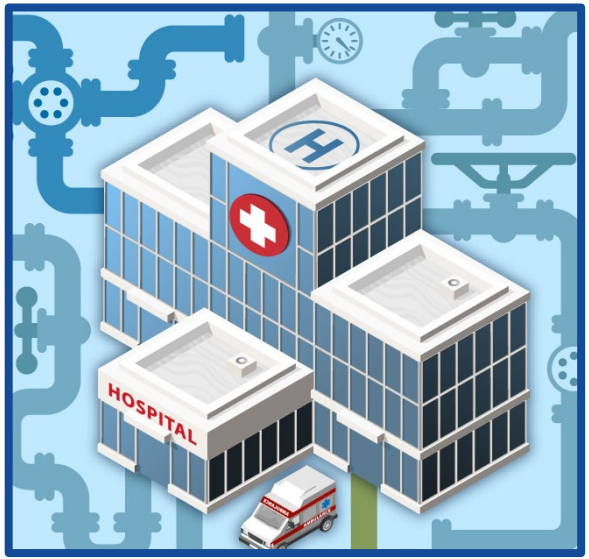
Water Management Programs

Recommendations and Resources

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

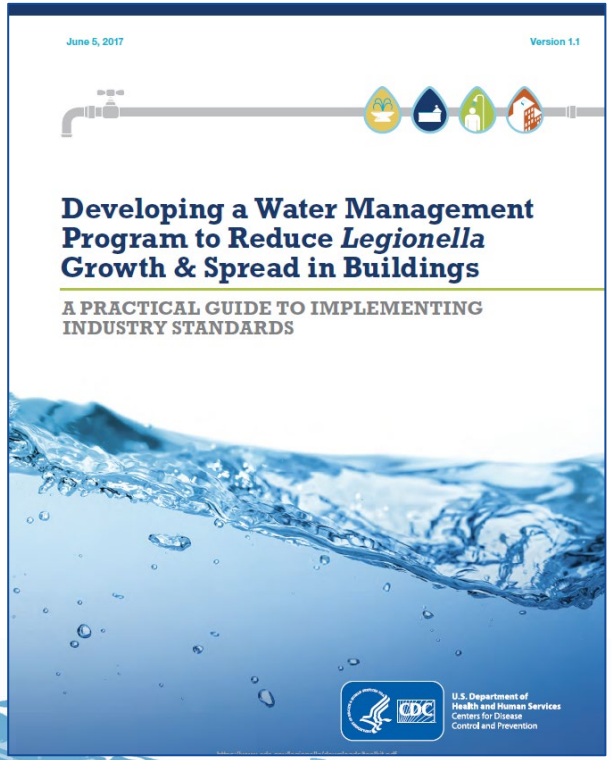
Water Management Programs (WMPs)

- Needed to identify hazardous conditions and minimize the growth and transmission of *Legionella* and other opportunistic pathogens in building water systems
- In 2017, the Centers for Medicare & Medicaid Service (CMS) began requiring that certified hospitals in the United States have water management policies and procedures



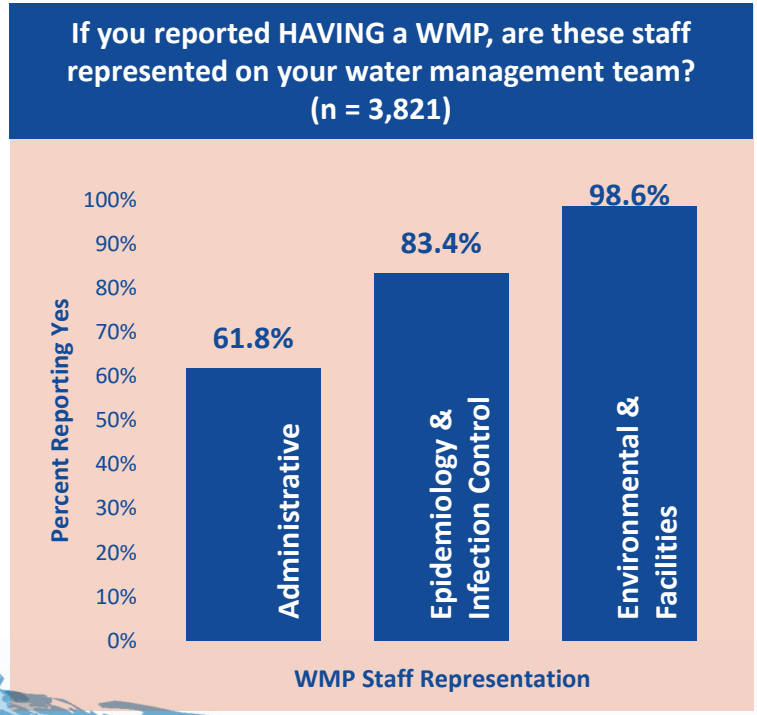
CDC *Legionella* toolkit

- Establish a WMP team
- Describe the building water systems
- Identify areas where *Legionella* could grow and spread
- Decide where control measures should be applied and how to monitor them
- Establish ways to intervene when control limits not met
- Make sure the program is running as designed and is effective
- Document and communicate all the activities



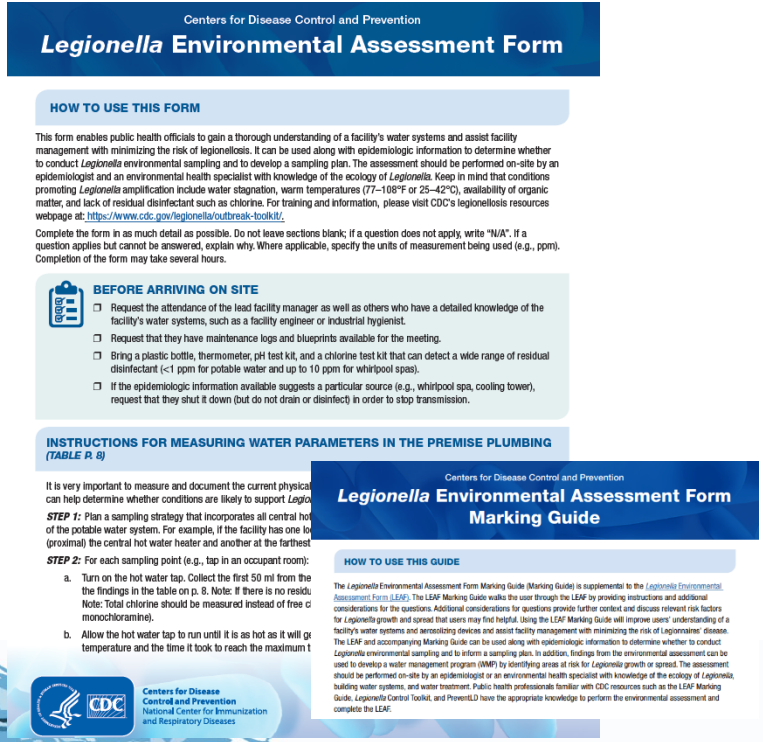
WMP Teams

- WMPs should be supported by engaged teams with diverse responsibilities
- Administrative
  - Hospital administrator, compliance officer, risk/quality management
- Epidemiology/infection control
  - Epidemiologist/infection preventionist, other clinical
- Environmental/facilities
  - Consultant, facility manager/engineer, equipment/chemical supplier, maintenance



Risk Assessments: Environmental

- CMS-certified healthcare facilities expected to:
  - Conduct a facility risk assessment to identify where *Legionella* and other opportunistic waterborne pathogens (e.g., *Pseudomonas*, *Acinetobacter*, *Burkholderia*, *Stenotrophomonas*, nontuberculous mycobacteria, and fungi) could grow and spread in the facility water system



Centers for Disease Control and Prevention

***Legionella* Environmental Assessment Form**

HOW TO USE THIS FORM

This form enables public health officials to gain a thorough understanding of a facility's water systems and assist facility management with minimizing the risk of legionellosis. It can be used along with epidemiologic information to determine whether to conduct *Legionella* environmental sampling and to develop a sampling plan. The assessment should be performed on-site by an epidemiologist and an environmental health specialist with knowledge of the ecology of *Legionella*. Keep in mind that conditions promoting *Legionella* amplification include water stagnation, warm temperatures (77–108°F or 25–42°C), availability of organic matter, and lack of residual disinfectant such as chlorine. For training and information, please visit CDC's legionellosis resources webpage at: https://www.cdc.gov/legionella/outbreak-toolkit/.

Complete the form in as much detail as possible. Do not leave sections blank; if a question does not apply, write "N/A". If a question applies but cannot be answered, explain why. Where applicable, specify the units of measurement being used (e.g., ppm). Completion of the form may take several hours.

BEFORE ARRIVING ON SITE

- ❒ Request the attendance of the lead facility manager as well as others who have a detailed knowledge of the facility's water systems, such as a facility engineer or industrial hygienist.
- ❒ Request that they have maintenance logs and blueprints available for the meeting.
- ❒ Bring a plastic bottle, thermometer, pH test kit, and a chlorine test kit that can detect a wide range of residual disinfectant (<1 ppm for potable water and up to 10 ppm for whirlpool spas).
- ❒ If the epidemiologic information available suggests a particular source (e.g., whirlpool spa, cooling tower), request that they shut it down (but do not drain or disinfect) in order to stop transmission.

INSTRUCTIONS FOR MEASURING WATER PARAMETERS IN THE PREMISE PLUMBING *(TABLE P. 8)*

It is very important to measure and document the current physica
can help determine whether conditions are likely to support *Legio*

STEP 1: Plan a sampling strategy that incorporates all central ho
of the potable water system. For example, if the facility has one lo
(proximal) the central hot water heater and another at the farthest

STEP 2: For each sampling point (e.g., tap in an occupant room):

a. Turn on the hot water tap. Collect the first 50 ml from the
the findings in the table on p. 8. Note: If there is no residu
Note: Total chlorine should be measured instead of free c
monochloramine).

b. Allow the hot water tap to run until it is as hot as it will g
temperature and the time it took to reach the maximum t

Centers for Disease Control and Prevention

***Legionella* Environmental Assessment Form Marking Guide**

HOW TO USE THIS GUIDE

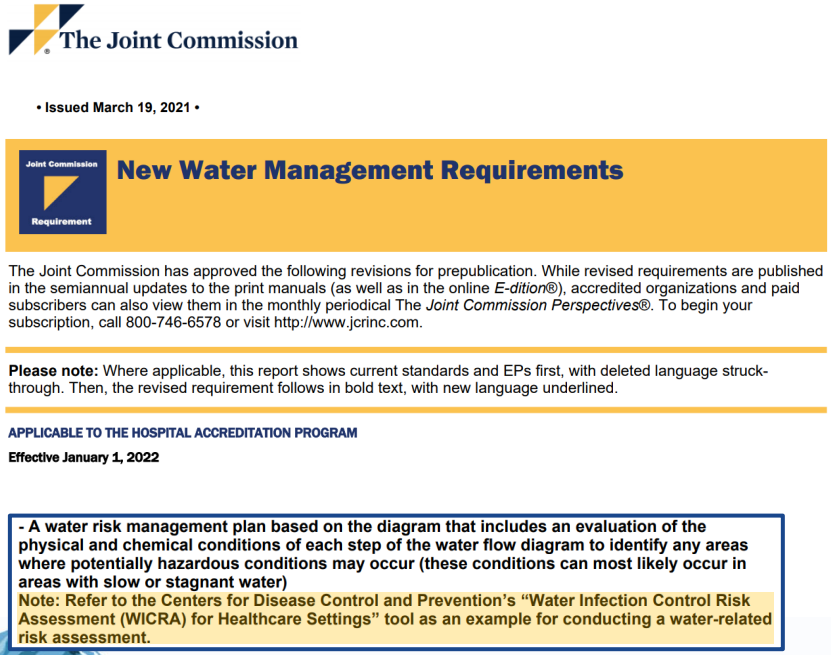
The *Legionella* Environmental Assessment Form Marking Guide (Marking Guide) is supplemental to the *Legionella* Environmental Assessment Form (LEAF). The LEAF Marking Guide walks the user through the LEAF by providing instructions and additional considerations for the questions. Additional considerations for questions provide further context and discuss relevant risk factors for *Legionella* growth and spread that users may find helpful. Using the LEAF Marking Guide will improve users' understanding of a facility's water systems and aerosolizing devices and assist facility management with minimizing the risk of Legionnaires' disease. The LEAF and accompanying Marking Guide can be used along with epidemiologic information to determine whether to conduct *Legionella* environmental sampling and to inform a sampling plan. In addition, findings from the environmental assessment can be used to develop a water management program (WMP) by identifying areas at risk for *Legionella* growth or spread. The assessment should be performed on-site by an epidemiologist or an environmental health specialist with knowledge of the ecology of *Legionella*, building water systems, and water treatment. Public health professionals familiar with CDC resources such as the LEAF Marking Guide, *Legionella* Control Toolkit, and PreventLD have the appropriate knowledge to perform the environmental assessment and complete the LEAF.

Centers for Disease Control and Prevention
National Center for Immunization and Respiratory Diseases

https://www.cdc.gov/legionella/health-depts/environmental-inv-resources.html

Risk Assessments: Infection Control

- New TJC water management requirements:
  - Water infection control risk assessment (WICRA)



The Joint Commission

• Issued March 19, 2021 •

Joint Commission Requirement

New Water Management Requirements

The Joint Commission has approved the following revisions for prepublication. While revised requirements are published in the semiannual updates to the print manuals (as well as in the online *E-dition*®), accredited organizations and paid subscribers can also view them in the monthly periodical The *Joint Commission Perspectives*®. To begin your subscription, call 800-746-6578 or visit http://www.jcrinc.com.

Please note: Where applicable, this report shows current standards and EPs first, with deleted language struck-through. Then, the revised requirement follows in bold text, with new language underlined.

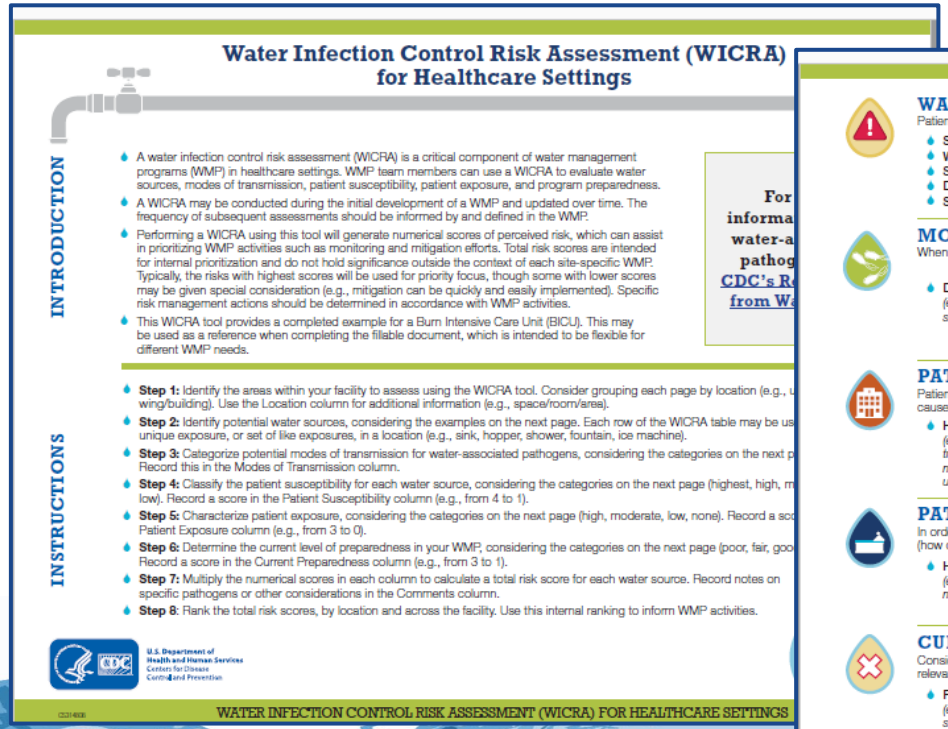
APPLICABLE TO THE HOSPITAL ACCREDITATION PROGRAM

Effective January 1, 2022

- A water risk management plan based on the diagram that includes an evaluation of the physical and chemical conditions of each step of the water flow diagram to identify any areas where potentially hazardous conditions may occur (these conditions can most likely occur in areas with slow or stagnant water)
Note: Refer to the Centers for Disease Control and Prevention's "Water Infection Control Risk Assessment (WICRA) for Healthcare Settings" tool as an example for conducting a water-related risk assessment.

Water Infection Control Risk Assessment (WICRA)

https://www.cdc.gov/hai/pdfs/prevent/water-assessment-tool-508.pdf



Water Infection Control Risk Assessment (WICRA) for Healthcare Settings

INTRODUCTION

- A water infection control risk assessment (WICRA) is a critical component of water management programs (WMP) in healthcare settings. WMP team members can use a WICRA to evaluate water sources, modes of transmission, patient susceptibility, patient exposure, and program preparedness.
- A WICRA may be conducted during the initial development of a WMP and updated over time. The frequency of subsequent assessments should be informed by and defined in the WMP.
- Performing a WICRA using this tool will generate numerical scores of perceived risk, which can assist in prioritizing WMP activities such as monitoring and mitigation efforts. Total risk scores are intended for internal prioritization and do not hold significance outside the context of each site-specific WMP. Typically, the risks with highest scores will be used for priority focus, though some with lower scores may be given special consideration (e.g., mitigation can be quickly and easily implemented). Specific risk management actions should be determined in accordance with WMP activities.
- This WICRA tool provides a completed example for a Burn Intensive Care Unit (BICU). This may be used as a reference when completing the fillable document, which is intended to be flexible for different WMP needs.

For informa… water-a… pathog… CDC's R… from W…

INSTRUCTIONS

- **Step 1:** Identify the areas within your facility to assess using the WICRA tool. Consider grouping each page by location (e.g., u… wing/building). Use the Location column for additional information (e.g., space/room/area).
- **Step 2:** Identify potential water sources, considering the examples on the next page. Each row of the WICRA table may be us… unique exposure, or set of like exposures, in a location (e.g., sink, hopper, shower, fountain, ice machine).
- **Step 3:** Categorize potential modes of transmission for water-associated pathogens, considering the categories on the next p… Record this in the Modes of Transmission column.
- **Step 4:** Classify the patient susceptibility for each water source, considering the categories on the next page (highest, high, m… low). Record a score in the Patient Susceptibility column (e.g., from 4 to 1).
- **Step 5:** Characterize patient exposure, considering the categories on the next page (high, moderate, low, none). Record a sc… Patient Exposure column (e.g., from 3 to 0).
- **Step 6:** Determine the current level of preparedness in your WMP, considering the categories on the next page (poor, fair, goo… Record a score in the Current Preparedness column (e.g., from 3 to 1).
- **Step 7:** Multiply the numerical scores in each column to calculate a total risk score for each water source. Record notes on specific pathogens or other considerations in the Comments column.
- **Step 8:** Rank the total risk scores, by location and across the facility. Use this internal ranking to inform WMP activities.

U.S. Department of Health and Human Services, Centers for Disease Control and Prevention

WATER INFECTION CONTROL RISK ASSESSMENT (WICRA) FOR HEALTHCARE SETTINGS

WATER SOURCES

Patients are potentially exposed to water via the healthcare environment, equipment, or procedures. Water sources include, but are not limited to:

- Sinks
- Water source
- Sinks
- Drains
- Showers
- Toilets
- Hoppers
- Humidification devices
- Mechanical ventilators
- Endoscopes
- Heater cooler devices
- Ice machines
- Indoor decorative fountains
- Lactation equipment
- Enteral feeding
- Bathing procedures
- Oral care

MODES OF TRANSMISSION

When assessing risk of healthcare-associated infections caused by waterborne pathogens, consider the diverse modes of transmission, including:

- **Direct contact** *(e.g., bathing, showering)*
- **Ingestion of water** *(e.g., consumption of contaminated ice)*
- **Indirect contact** *(e.g., from an improperly reprocessed medical device)*
- **Inhalation of aerosols dispersed from water sources** *(e.g. faucets with aerators)*
- **Aspiration of contaminated water** *(e.g. use of tap water to flush enteral feedings)*

PATIENT SUSCEPTIBILITY

Patient populations with compromised immune status, comorbidities, and exposure to certain procedures are more vulnerable to infections caused by waterborne pathogens. Units/wards/wings can be classified according to those patients treated in these areas:

- **Highest** *(e.g., BMT, solid-organ transplant, hematology, medical oncology, burn unit, NICU)*
- **High** *(e.g., non-transplant ICUs, ORs)*
- **Moderate** *(e.g., general inpatient units)*
- **Low** *(e.g., waiting rooms, administrative office areas)*

PATIENT EXPOSURE

In order to characterize patient exposure to water sources, consider a categorization scheme that encompasses factors such as the frequency (how often), magnitude (how much), and duration (how long) of exposure:

- **High** *(e.g., high frequency, magnitude, and duration)*
- **Moderate** *(e.g., combination of high and low frequency, magnitude, and duration)*
- **Low** *(e.g., low frequency, magnitude, and duration)*
- **None** *(e.g., patients are not exposed to the water source)*

CURRENT PREPAREDNESS

Consider how your WMP addresses different water sources, as determined by factors such as policies and procedures already in place, relevant staff practice, and implemented mitigation strategies.

- **Poor** *(e.g., limited policies and procedures, staff practice, and mitigation strategies)*
- **Fair** *(e.g., some policies and procedures, staff practice, and mitigation strategies)*
- **Good** *(e.g., robust policies and procedures, staff practice, and mitigation strategies)*

WATER INFECTION CONTROL RISK ASSESSMENT (WICRA) FOR HEALTHCARE SETTINGS

New CDC WICRA Tool

https://www.cdc.gov/hai/pdfs/prevent/water-assessment-tool-508.pdf

Water Infection Control Risk Assessment (WICRA) for Healthcare Settings

Facility Name: Hospital A **Assessment Location:** Burn ICU

Performed By (names): Jane Smith and John Doe **Assessment Date:** 10/01/2020

WMP Team Role(s) *(check all that apply):*

- ☑ Hospital Epidemiologist/Infection Preventionist
- ☑ Facilities Manager/Engineer
- ☐ Environmental Services
- ☐ Compliance/Safety Officer
- ☐ Risk/Quality Management Staff
- ☐ Infectious Disease Clinician
- ☐ Consultant
- ☐ Equipment/Chemical Acquisition/Supplier
- ☐ Other *(please specify)*:

Location	Water Source	Modes of Transmission	Patient Susceptibility Highest = 4 High = 3 Moderate = 2 Low = 1	Patient Exposure High = 3 Moderate = 2 Low = 1 None = 0	Current Preparedness Poor = 3 Fair = 2 Good = 1	Total Risk Score = Patient Susceptability x Patient Exposure x Preparedness	Comments
BICU Inpatient Rooms	Sink counter storage of patient care supplies	Indirect contact; splashing onto supplies	4	3	3	36	Install splash guards; QI for sink hygiene; and flushing
BICU Inpatient Rooms	Toilets without lid	Direct contact	4	3	2	24	Place lid on toilet if in patient room
BICU Soiled Utility	Hopper, no lid, behind closed door	Indirect contact	4	2	1	8	Automatic door closure; appropriate soiled equipment storage
BICU Medication Preparation Room	Sink with aerator, no splash guard	Aerosolization, and potential for splashing	4	2	3	24	Install splash guards; evaluate removing aerator
BICU Hydrotherapy Room	Debridement showers	Direct contact	4	3	1	12	Monthly EVS audits room indicating 95% adherence to policies
BICU Nurses Station	Sink closest to door	Indirect contact; HCW hands; devices	4	2	3	24	Install splash guards or move IV bags storage

Background

Outbreaks

Multidrug-Resistant Organisms

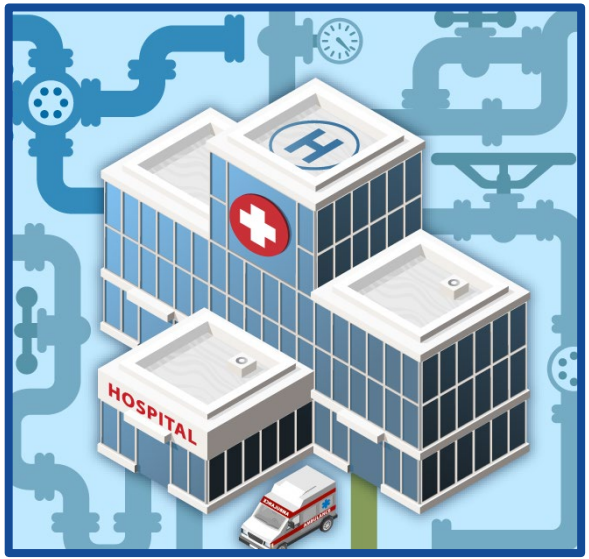
Water Management Programs

Recommendations and Resources

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Take-Home Messages

- WMPs should be supported by actively engaged teams with diverse responsibilities
  - Infection preventionists play a key role
- Environmental assessments and water infection control risk assessments are central to WMP functions
  - It's not just *Legionella pneumophilia*

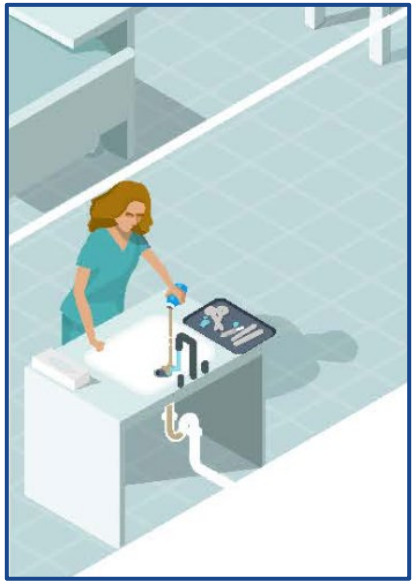


Take-Home Messages

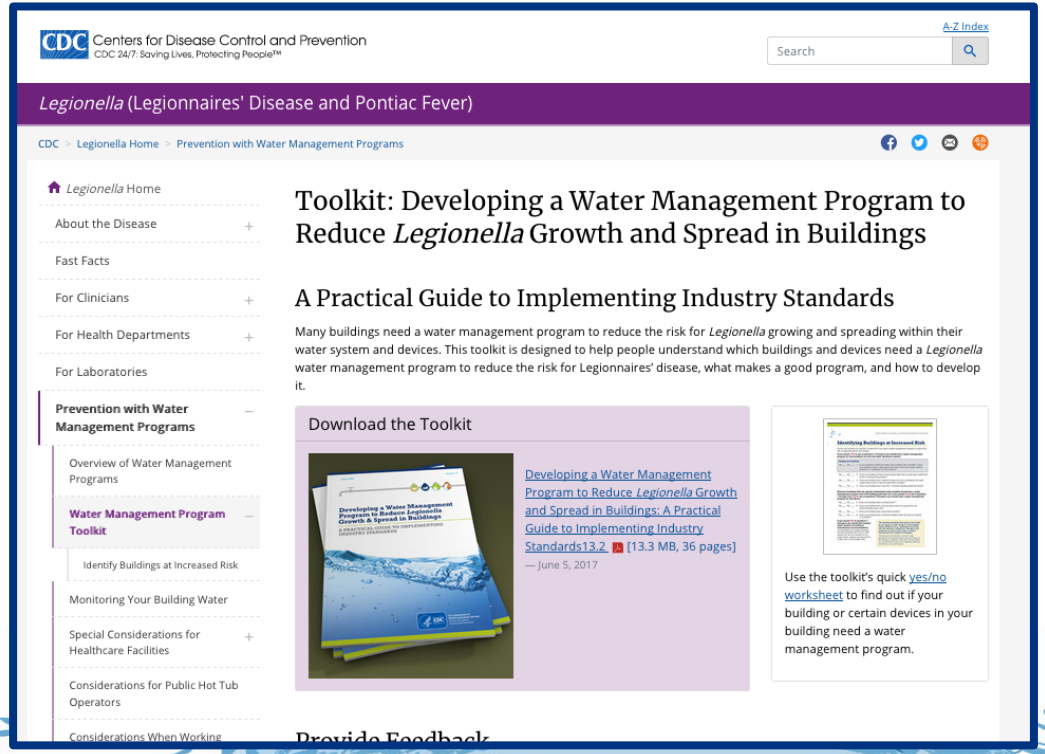
- Reduce splash in patient care areas
  - Offset faucets to prevent water from discharging directly above the drain
  - Use sinks with adequate depth and water flow rate
  - Install and use hopper and toilet covers (close covers before flushing)
  - If hopper and toilet covers are unavailable, close the door separating the hopper or toilet from other patient care areas before flushing

Take-Home Messages

- Clean and disinfect sink basin, faucet, faucet handles, and surrounding countertop at least daily
- Keep patient care and personal items away from sinks
- Discard patient waste in toilets or hoppers (not sinks)
- Avoid discarding liquid nutritional supplements or beverages into sinks or toilets

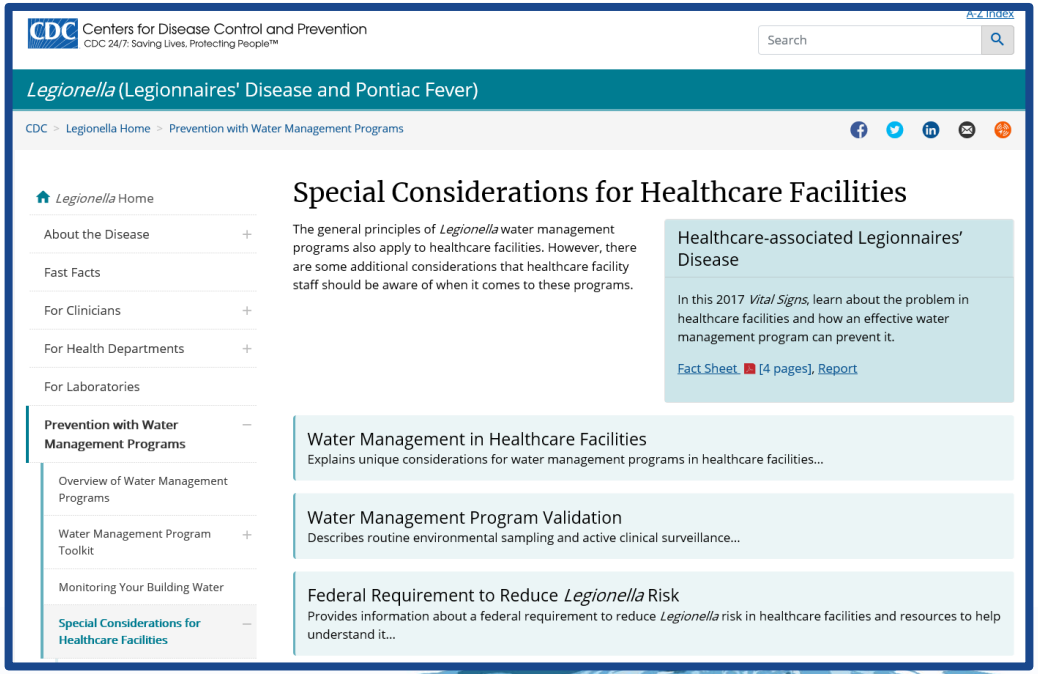


CDC *Legionella* Toolkit



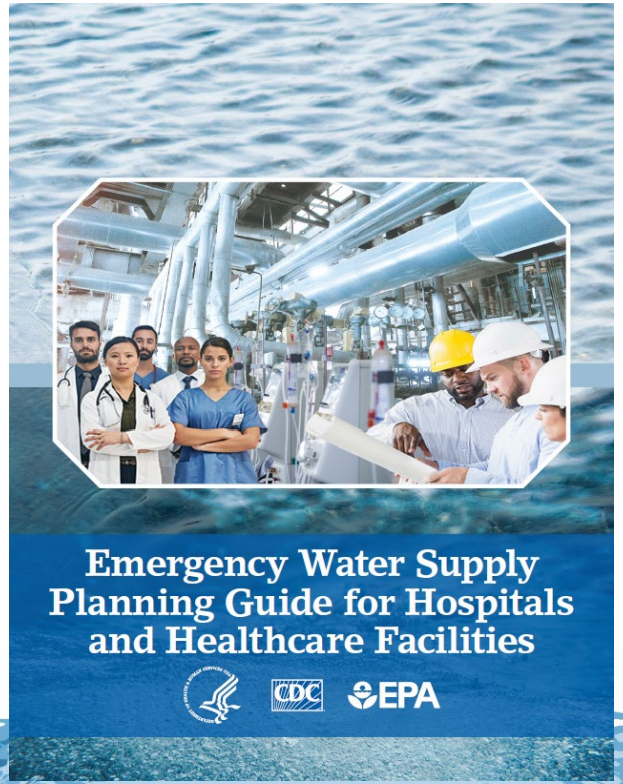
https://www.cdc.gov/legionella/wmp/toolkit/index.html

CDC *Legionella* Toolkit



https://www.cdc.gov/legionella/wmp/healthcare-facilities/index.html

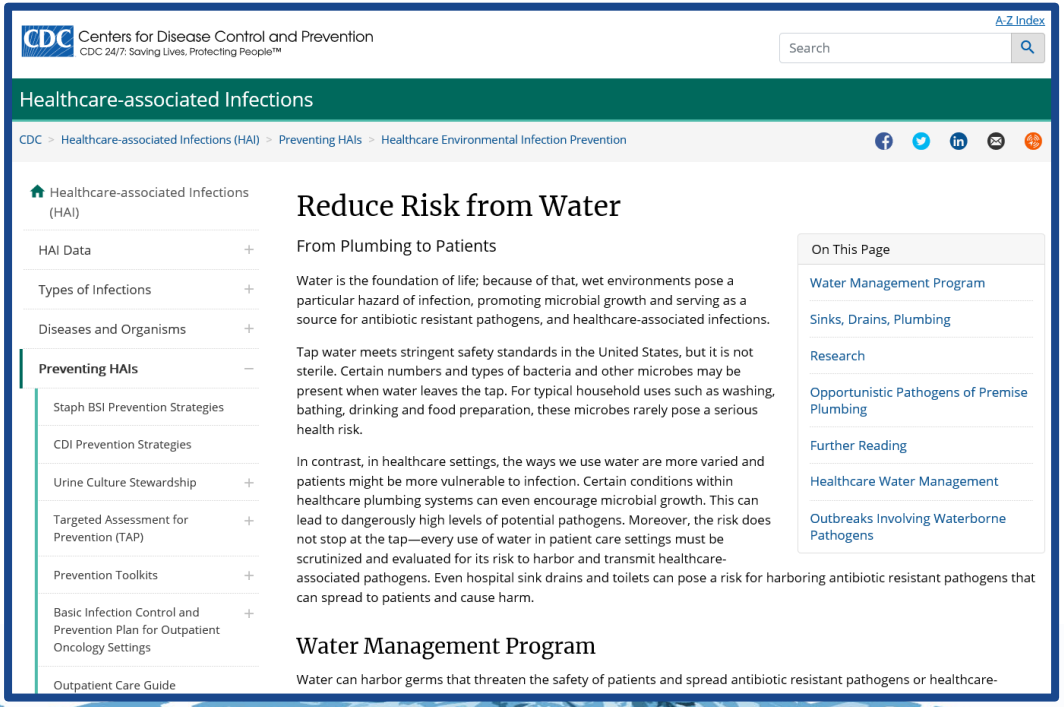
Emergency Water Supply Planning Guide



https://www.cdc.gov/healthywater/emergency/ewsp.html

Reduce Risk from Water: From Plumbing to Patients

https://www.cdc.gov/hai/prevent/environment/water.html



View Larger

Tools

- Water Infection Control Risk Assessment (WICRA) for Healthcare Settings [PDF – 5 pages]
- Tap Water Quality and Infrastructure Discussion Guide for Investigation of Potential Water-Associated Infections in Healthcare Facilities [PDF – 5 pages]
- Healthcare Facility Water Management Program Checklist [PDF – 4 pages]
- Infection Control Assessment Tools

Reduce Risk from Water: From Plumbing to Patients

Healthcare Facility Water Management Program Checklist

Available from: www.cdc.gov/hai/prevent/water-management.html

This checklist is intended to assist in the development of an all-hazards approach to water management in a healthcare facility, and may be used to:

- Evaluate a comprehensive water management program.
- Identify individuals to participate in the water management program.
- Assist in conducting assessments, including hazard analyses, environmental risk assessments, and infection control risk assessments.
- Inform water monitoring practices guided by the management program.

Depending on complexity of the building plumbing systems, a comprehensive program may include several water management plans. These plans should include areas within the system where control points are identified as well as monitoring methods and procedures.

Establish a Water Management Program Team

For all facility types, establish clear lines of communication to facilitate dialogue with representatives from the water utility/drinking water provider, as well as the local health department, on an as needed basis.

☐ Define membership (at a minimum, the following 'roles' should be represented; may include others depending on facility size, type
- facility administration/ownership or C-Suite
- facilities management
- facilities engineer
- infection prevention

☐ Develop a charter that defines roles and responsibilities of members, chair, meeting schedule, etc.

☐ Have you identified team members who should:

☐ Y ☐ N Be familiar with the facility water system(s)

☐ Y ☐ N Identify control locations and control limits

☐ Y ☐ N Identify and take corrective actions

☐ Y ☐ N Monitor and document program performance

For nursing homes, the group may consist of three or more individuals representing management, nursing (someone filling the role of infection control), and the facilities engineer; ad hoc members with subject matter expertise (to provide advice) may be water consultants.

Larger facilities representation may include a designee from the C-suite, risk management, infection prevention, facilities engineers, central services, laboratory, and ad hoc members from clinical departments or water consultants.

Tap Water Quality and Infrastructure Discussion Guide for Investigation of Potential Water-Associated Infections in Healthcare Facilities

Available from: www.cdc.gov/hai/prevent/water-management.html

Purpose: For CDC and health department to use as a discussion guide when consulting with healthcare facilities in situations where there is concern for transmission of waterborne pathogens. Patient exposures may either be direct (aerosols, splash, bathing, ingestion, ice use, contaminated devices with water reservoirs, etc.) or indirect (contaminated surfaces, reprocessed medical devices, drugs, healthcare personnel, etc.). Examples of infections might include surgical site, injection site, or bloodstream infections due to nontuberculous mycobacteria; *Pseudomonas aeruginosa* infections among NICU or burn patients; Legionnaires' disease.

1. Drinking Water System Name (Public or Private): _____

2. If Public Water System, EPA ID Number: _____
   To find your EPA ID Number, use SDWIS Search (https://www.epa.gov/enviro/sdwis-search).

3. Water Source (*check*):
   a. ☐ Surface water

CDC WICRA Tool

Water Infection Control Risk Assessment (WICRA) for Healthcare Settings

INTRODUCTION

- A water infection control risk assessment (WICRA) is a critical component of water management programs (WMP) in healthcare settings. WMP team members can use a WICRA to evaluate water sources, modes of transmission, patient susceptibility, patient exposure, and program preparedness.
- A WICRA may be conducted during the initial development of a WMP and updated over time. The frequency of subsequent assessments should be informed by and defined in the WMP.
- Performing a WICRA using this tool will generate numerical scores of perceived risk, which can assist in prioritizing WMP activities such as monitoring and mitigation efforts. Total risk scores are intended for internal prioritization and do not hold significance outside the context of each site-specific WMP. Typically, the risks with highest scores will be used for priority focus, though some with lower scores may be given special consideration (e.g., mitigation can be quickly and easily implemented). Specific risk management actions should be determined in accordance with WMP activities.
- This WICRA tool provides a completed example for a Burn Intensive Care Unit (BICU). This may be used as a reference when completing the fillable document, which is intended to be flexible for different WMP needs.

For informa water-a pathog CDC's R from W

INSTRUCTIONS

- **Step 1:** Identify the areas within your facility to assess using the WICRA tool. Consider grouping each page by location (e.g., u wing/building). Use the Location column for additional information (e.g., space/room/area).
- **Step 2:** Identify potential water sources, considering the examples on the next page. Each row of the WICRA table may be us unique exposure, or set of like exposures, in a location (e.g., sink, hopper, shower, fountain, ice machine).
- **Step 3:** Categorize potential modes of transmission for water-associated pathogens, considering the categories on the next p Record this in the Modes of Transmission column.
- **Step 4:** Classify the patient susceptibility for each water source, considering the categories on the next page (highest, high, m low). Record a score in the Patient Susceptibility column (e.g., from 4 to 1).
- **Step 5:** Characterize patient exposure, considering the categories on the next page (high, moderate, low, none). Record a sc Patient Exposure column (e.g., from 3 to 0).
- **Step 6:** Determine the current level of preparedness in your WMP, considering the categories on the next page (poor, fair, goo Record a score in the Current Preparedness column (e.g., from 3 to 1).
- **Step 7:** Multiply the numerical scores in each column to calculate a total risk score for each water source. Record notes on specific pathogens or other considerations in the Comments column.
- **Step 8**: Rank the total risk scores, by location and across the facility. Use this internal ranking to inform WMP activities.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

WATER SOURCES

Patients are potentially exposed to water via the healthcare environment, equipment, or procedures. Water sources include, but are not limited to:

- Sinks
- Water source
- Sinks
- Drains
- Showers
- Toilets
- Hoppers
- Humidification devices
- Mechanical ventilators
- Endoscopes
- Heater cooler devices
- Ice machines
- Indoor decorative fountains
- Lactation equipment
- Enteral feeding
- Bathing procedures
- Oral care

MODES OF TRANSMISSION

When assessing risk of healthcare-associated infections caused by waterborne pathogens, consider the diverse modes of transmission, including:

- **Direct contact** *(e.g., bathing, showering)*
- **Ingestion of water** *(e.g., consumption of contaminated ice)*
- **Indirect contact** *(e.g., from an improperly reprocessed medical device)*
- **Inhalation of aerosols dispersed from water sources** *(e.g. faucets with aerators)*
- **Aspiration of contaminated water** *(e.g. use of tap water to flush enteral feedings)*

PATIENT SUSCEPTIBILITY

Patient populations with compromised immune status, comorbidities, and exposure to certain procedures are more vulnerable to infections caused by waterborne pathogens. Units/wards/wings can be classified according to those patients treated in these areas:

- **Highest** *(e.g., BMT, solid-organ transplant, hematology, medical oncology, burn unit, NICU)*
- **High** *(e.g., non-transplant ICUs, ORs)*
- **Moderate** *(e.g., general inpatient units)*
- **Low** *(e.g., waiting rooms, administrative office areas)*

PATIENT EXPOSURE

In order to characterize patient exposure to water sources, consider a categorization scheme that encompasses factors such as the frequency (how often), magnitude (how much), and duration (how long) of exposure:

- **High** *(e.g., high frequency, magnitude, and duration)*
- **Moderate** *(e.g., combination of high and low frequency, magnitude, and duration)*
- **Low** *(e.g., low frequency, magnitude, and duration)*
- **None** *(e.g., patients are not exposed to the water source)*

CURRENT PREPAREDNESS

Consider how your WMP addresses different water sources, as determined by factors such as policies and procedures already in place, relevant staff practice, and implemented mitigation strategies.

- **Poor** *(e.g., limited policies and procedures, staff practice, and mitigation strategies)*
- **Fair** *(e.g., some policies and procedures, staff practice, and mitigation strategies)*
- **Good** *(e.g., robust policies and procedures, staff practice, and mitigation strategies)*

WATER INFECTION CONTROL RISK ASSESSMENT (WICRA) FOR HEALTHCARE SETTINGS

Thank you!

Matt Arduino: mja4@cdc.gov
Alicia Shugart: vet2@cdc.gov
Matt Stuckey: lxo5@cdc.gov
CDC HAI/AR: HAIAR@cdc.gov

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov