



Waterborne Pathogens: Don't Overlook Legionella

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"It is better to be looked over than overlooked"

Mae West




Legionella is Overlooked

- This disease continues to be underdiagnosed (missed)
- Aversion to knowing
- Monitoring – Don't be Fooled
- Myths
 - Legionella is everywhere
 - It is costly to control/monitor
 - I'm not responsible if I don't know

Aversion to Knowing

"If you don't look for it, you won't find it."
If you don't find it, you don't think you have a problem.
If you don't think you have a problem, you don't do anything about it."



Bruce Dixon, M.D. Director,
Allegheny Co. Health Dept.


Costly to Overlook Legionella

- Real Numbers from a Hospital Outbreak
 - Administrations Time Lost = **\$125,000**
 - Remediation = **\$200,000-\$330,000**
 - Legal Counsel = **\$500,000-\$1 Million**
 - Public Relations = **\$50,000-\$75,000**
 - Lost Revenue = **Unable to quantify**
 - Outside Consultation = **\$5,000-\$100,000**
- Total = **\$880,000-\$1,630,000 !!!!**
Courtesy G. Lyelo, EBSol, Inc.

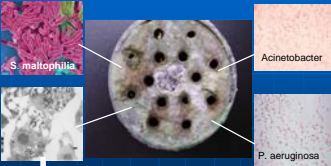
New Trends in Legionnaires' Disease

- The disease, reservoirs, transmission and risk
- The approaches to prevention & control
- Assessing risk – the role of environmental monitoring

What's in Your Water?



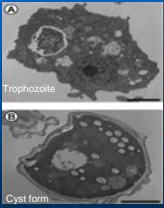
What's in Our Water (Biofilm)?



Legionella & Amoeba Resistant microorganisms (ARB)

Something New- Amoeba Resistant microorganisms

- Free-living amoebae (Hartmannella, Naegleria, Acanthamoeba) are abundant in water.
- They feed on microorganisms by phagocytosis
- Some of these ingested microorganisms are not destroyed- they survive, multiply and are released



Amoeba-resisting Bacteria

- Legionella spp.
- Mycobacterium avium
- Cryptococcus neoformans
- Pseudomonas aeruginosa

Clin. Microbiol. Reviews 2004

Symbiotic Microflora

- Amoebae
- Algae
- Bacteria

Amoebae Cyst form

Legionella Survival in Water

- Legionella are ingested by free living amoebae
- Legionella can survive within the cysts of amoebae at a free chlorine level of 50 mg/L.

Biofilm - Definition

- A community of microorganisms that is embedded in a matrix of extracellular polymers

Ice machine

LEGIONELLA A WATERY SURVIVAL

Biofilm - Definition

- "Slime" in all water systems
- Biofilms form on the surfaces of solid materials – think miles of pipe
- The efficiency of biocides is markedly reduced against biofilms. Chlorine will effectively control bacteria in bulk water, but not the biofilm.

Water Fixtures: More Scary Stuff

Friends or Foes?

Infect. Control Hosp. Epidemiol. 2001

Sensor Faucets: 2 steps forward, 3 steps back?

Figure 1. Diagram of the non-touch faucet.

Disturbing Findings

J Hosp Infect 2001;49:117-121

The Study

- Water samples from 38 non-touch taps tested. (with and without temperature selection) vs. 10 conventional taps
- 74% of non-touch taps without temp. selection were contaminated with *P. aeruginosa* vs. 7% with temp. selection, vs. 0% conventional taps.
- Legionella* found in all 38 non-touch taps, but only 3/10 conventional taps

Problems with non-touch fixtures

- The magnetic valve, the mixing device and outlet most contaminated
- Low water flow
- Lower hot water temperature
- Outcome = removed all non-touch taps and replaced with conventional taps!

Be old fashioned in high risk areas – avoid electronic faucets?

Should Electronic Faucets Be Recommended in Hospitals?

Iris F. Chaberry, MD; Petra Gastmeier, MD

ABSTRACT
Microbiological examinations of electronic faucets newly installed in a hospital kitchen revealed high bacteria counts and *Pseudomonas aeruginosa* during a 6-month period of observation. Our data suggest that the use of electronic faucets poses a potential risk for nosocomial infection in high-risk areas of hospitals. *Infect Control Hosp Epidemiol* 2004;29:1397-1399.

It's Not Just Legionella in the Water

- Pseudomonas aeruginosa*
- Stenotrophomonas maltophilia*
- Acinetobacter* spp.
- Mycobacteria* spp.

Ecology of *Pseudomonas aeruginosa* in the intensive care unit and the evolving role of water outlets as a reservoir of the organism

Nathalie Truchetet, MD, Philippe H. Legendre, MD, and Nathalie Sallenot, MD
Nantes, France, and Angers, France

Am J Infect Control 2005; 33:S41-49

Hospital Water as a Source of *Mycobacterium avium* Complex Isolates in Respiratory Specimens

Melissa J. Sabin-D'Angelo, Mitchell A. Elias, Carlos del Rio, J. Sue Holmes, Henry M. Blumberg, and C. Robert Horsburgh, Jr.
Division of Infectious Diseases, Department of Medicine, Emory University School of Medicine, and Grady Memorial Hospital, Atlanta, Georgia; Department of Epidemiology, Boston University School of Public Health, Boston, Massachusetts

Nosocomial outbreak of colonization and infection with *Stenotrophomonas maltophilia* in preterm infants associated with contaminated tap water

F. E. VERWIJF, J. F. G. M. MEIJ, V. CHRISTMANN, M. VAN DER BEEK, W. J. G. MELCHERS, B. G. M. HILDERINK, and A. VOSE
Department of Medical Microbiology, University Hospital Nijmegen, P.O. box 9101, 6500 HB Nijmegen, The Netherlands
Department of Pediatrics, Erasmus Hospital Nijmegen, Nijmegen, The Netherlands

Neonates at Risk for Legionella Infections

Legionella pneumophila Pneumonia in a Newborn after Water Birth: A New Mode of Transmission

Janet Hoyle, Sandy Smith, Steven Savel, "Morgue Man", and the "Morgue Men"
Department of Pediatric Infectious Diseases, University of Michigan Medical Center, Ann Arbor, Michigan

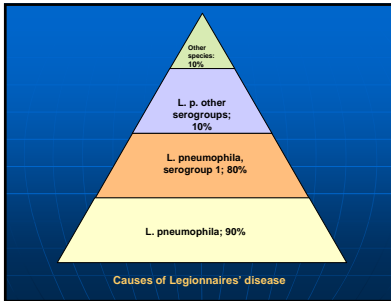
We report a case of Legionella pneumoniae pneumonia in a 7-day-old newborn. Between the hospital water and parents, only the water used for water birth was investigated for Legionella pneumoniae. The antibiotic was initiated for Legionella pneumoniae. The antibiotic was initiated for Legionella pneumoniae. The antibiotic was initiated for Legionella pneumoniae.

My Favorite Subject

- Legionnaires' disease is a multi-system illness, with pneumonia, caused by *Legionella* species.
- More than 18,000 cases per year (underestimate)
- Pontiac fever is a self-limited flu-like illness, without pneumonia, that is associated with legionella species. This illness resolves without treatment.

Legionella Species

- Gram negative bacterium – rod shaped
- >48 named species, over 60 serogroups
- Intracellular parasite- replicates in macrophages and amoebae
- L. pneumophila* (sg's 1-15) accounts for approx. 90% of cases reported to the CDC
- L. pneumophila*, serogroup 1 causes approx. 80% of cases (Most virulent)



Knowledge in All Areas = Prevention & Control

- The Disease**
 - How is it diagnosed?
 - Who is at risk?
 - How do you get it?
- Prevention**
 - Pro-active approaches
 - Disinfection options
 - Water distribution systems
 - Industrial (non-potable) systems
- Environmental testing**
 - What? Where? How?
 - Interpretation

Overlooked because the Symptoms of Legionnaires' Disease are non-specific!!

- Fever
- Malaise
- Cough
- Chills
- Shortness of breath
- Diarrhea



Who is at Risk?
People with a history of:

- Smoking
- Chronic lung disease
- Corticosteroids
- Diabetes
- Cancer
- Elderly
- Transplantation (highest risk)



Who Gets Legionnaires' Disease?
Data from 487 cases in Allegheny Co., PA

Male	60%
Mean age	64
Underlying Cancer	21%
Transplant	3%
Dialysis	4%
Steroids	24%
Other immunosuppressives	13%
Diabetes	19%
Smoker	39%
None of the above	26%

Who is at Greatest Risk?

- Immunocompromised patients
 - Solid Organ Transplant
 - Bone Marrow (HSCT) transplant
 - High dose steroids
- ICU (NICU) & Surgical patients



Risk of Acquiring Legionnaires' Disease is Multi-factorial

Legionella in water (reservoir) + Transmission to the host (exposure) + Susceptible Host

Legionella in water

↓

Sufficient inocula

↓

Susceptible host

↓

Index of suspicion

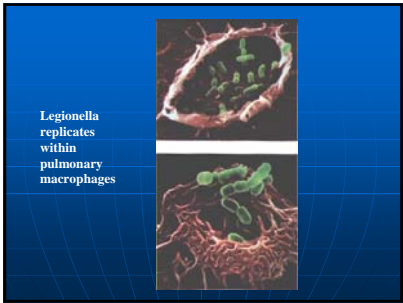
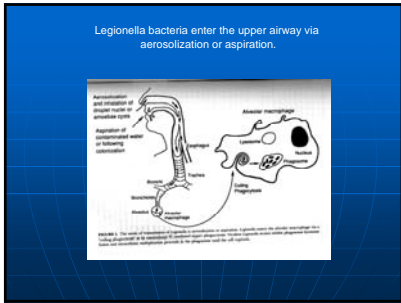
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Diagnostic tests available

↓

Legionnaires' disease

- Modes of Transmission of Legionnaires' disease
- Aerosolization
 - Aspiration
 - Direct instillation into the patient (tap water rinsing of Nasogastric tubes, respiratory tubing, etc)



- Treatment for Legionnaires' Disease
- | | |
|---|--|
| <ul style="list-style-type: none"> ■ Ineffective <ul style="list-style-type: none"> • Penicillins <ul style="list-style-type: none"> ▪ Amoxicillin • Cephalosporins | <ul style="list-style-type: none"> ■ Effective <ul style="list-style-type: none"> • Macrolides <ul style="list-style-type: none"> ▪ Erythromycin ▪ Azithromycin • Quinolones <ul style="list-style-type: none"> ▪ Ciprofloxacin ▪ Levofloxacin |
|---|--|

Where Can You be Exposed to Legionella?



New Trend: Legionnaires' Disease in Long-term Care Facilities

Toronto Deaths Are Probably From Legionnaires Disease (Update1)

OC 6 (Sloimberg) - Toronto health officials identified Legionnaires Disease, a form of pneumonia, as the probable cause of death of 16 people at a nursing home in the city.

Autopsy results on three of the dead residents of the Seven Oaks Home for the Aged showed Leg pneumophila, the bacterium that causes Legionnaires, Toronto Public Health said in statement to

"The Legionnaires Disease at Seven Oaks is confined to the nursing home," David McKee, T.C. officer of health, said in the statement. "Because Legionnaires Disease is not transmitted from person to person, there is no risk to the general community."

Equity Strategists: Cut Holdings of GI Stocks, Lehman's Scott Says

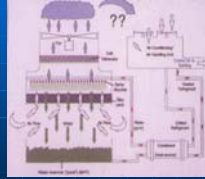
Angsey Mining Shares Rise on Lahn: Project Option in Canada

Legionella Outbreaks and Implicated Reservoirs

Murcia, Spain - 600 – 800 cases; **Cooling tower?**
 Paris, France - 12 cases/ 6 deaths; **Hospital water supply**
 Stavanger, Norway - 17 cases/2 deaths; **Decorative fountain?**

Melbourne, Australia - >100 cases; **aquarium cooling tower**
 Japan - 14 cases; **public bath**
 Pamplona, Spain-18 cases/3 deaths, **hospital water supply**

Cooling towers are not a common source for sporadic and hospital-acquired cases, but are more commonly associated with large community outbreaks



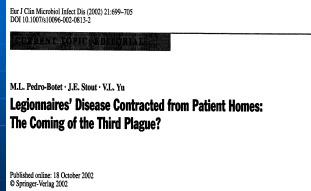
Cases of Legionnaires' Disease

- **Potable Water**, especially in hospitals (and other buildings) with complex hot water systems, is the **most important source** of Legionella transmission.

Cases of Legionnaires' Disease have been Linked to the Following Water Systems

- Warm water distribution systems of:
 - Hospitals, nursing homes, rehabilitation centers
 - Office Buildings
 - Apartment Buildings
 - Hotels
 - Residential/homes
- Spas and Hot tubs
- Decorative Fountains
- Humidifiers
- Cooling Towers

Private Residences



The number of cases of Legionnaires' disease has risen sharply



The number of cases of Legionnaires' disease continues to rise



Why the Increase in Reported Cases?

- Environmental factors?
- Better reporting?
- Increase in diagnostic testing****
 - It's not an outbreak, it's an "outbreak of diagnosis"

Environmental Factors: Origins of Waterborne Pathogens

- Incoming potable water (very low conc.)
- Systems with warm water, such as water distributions systems and air cooling systems (provide growth factors)
- Biofilms within these systems (amplification)

Legionella is Chlorine Tolerant

- 99% kill at 0.1 mg/L free chlorine required 40 min.
- 99% kill of E. coli required < 1.0 min.
- 4-6 mg/L to achieve a 5 log decrease in Legionella over 6 hours.

Factors Associated with Positive Water Systems, but NOT Predictive

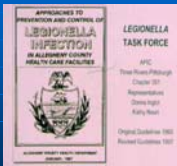
- Lower hot water temperatures (<50° C)
- Higher calcium (30 vs 21 mg/L) magnesium (10 vs. 5.5 mg/L), iron 265 vs. 130 ug/L).
- Older hot water systems, nonmunicipal water supplies, plumbing construction or repair.
- Low chlorine residuals

Environmental Conditions that Promote Legionella Growth

- Temperatures between 25°C and 50°C (77°F - 122°F)
- Microbial Flora - symbiosis
- Biofilm

Approach to Prevention of Legionnaires' Disease: Environmental Monitoring

- Pro-Active - ACHD
 - Initiate environmental testing now!
 - if >30% sites positive for L. pneumophila, intensify clinical surveillance for cases
 - If cases identified, then
 - Consider disinfection



NY State Requires Environmental Monitoring in High Risk Areas

- Laboratory Testing
 - Test by culture **AND** urine antigen
 - Save isolates
- Educate clinicians OR culture all respiratory specimens for Legionella
- Semiannual review of test usage
- Environmental Testing/maintenance
 - Quarterly culturing for Legionella from transplant units (HSCT or solid organ)
 - Hot water 51°C or semiannual high temp or chlorine flush
 - Clean/disinfect showerheads & aerators monthly

Legionella Guidance



Joint Commission for Accreditation of Hospital Organization

- In January of 2001, the JCAHO issued a new Environment of Care Standard - EC. Utility Systems Management
- Hospitals should have a plan for "managing pathogenic biological agents in cooling towers, domestic hot water, and other aerosolizing water systems"

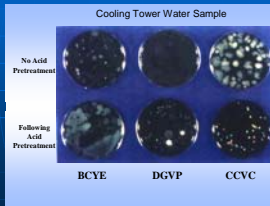
Tips...Maintenance and Legionella

- Important, but **OVER**-emphasized factor in minimizing the presence of Legionella in water systems.
- Legionella has been shown to colonize systems that appear to be well maintained.

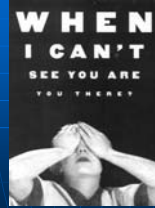
Tip...Temperature and Legionella

- Important for multiplication/amplification in water systems
- Optimal growth near body temperature (98°F)
- Hot water storage temperatures of 130-140°F (50-60°C) will help reduce, but **will not** eliminate Legionella from a colonized system.

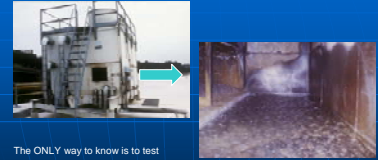
Legionella Isolation from Environmental Samples Requires Selective Media & Acid Pretreatment



Legionella Monitoring



Can You See the Legionella?



The ONLY way to know is to test

>3000 CFU/mL isolated

Defining the Risk Associated with the Presence of Legionella in Water

What is the acceptable upper limit of Legionella in potable water and cooling towers?

Risk Assessment – Stating the Obvious

- The risk factor (Legionella concentration) should correlate with the occurrence of disease.
- Disease should occur more often when this risk criteria is met.
- What is the data that supports this risk criteria/action levels?

Interpretation – Cooling Towers

Legionella per ml	Cooling Tower	Potable Water
1-9	A	B
10-99	B	C
100-999	C	D
1,000+	D	E
	E	E

Key:
 A = Low level of concern
 B = The high level of concern approximates this concern but indicates the system is a potential source of exposure
 C = Low but increased level of concern. Disinfection should be considered
 D = Intermediate/High levels. Appropriate levels that may cause outbreaks. Disinfect system
 E = Very high levels. Outbreak potential. Shut hot system immediately

Important - Limitations of the Data

- Original data upon which this risk criteria is based is limited.
- How limited (weak) is the data?
 - 675 cooling tower samples from 258 facilities
 - How many were outbreak-related facilities?
 - Would you believe...two!

Shelton, B.G. et al. Curr Microbiol. 28:359-363, 1994

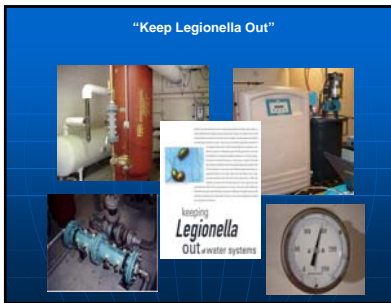
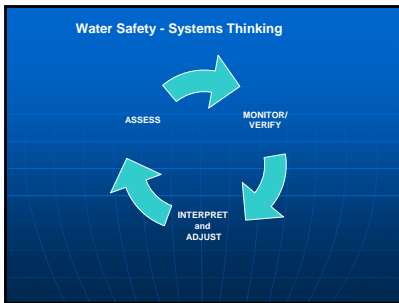
Potential Health Concern

- If a water sample from a cooling tower (or a whirlpool spa) has >1000 cfu/mL of *L. pneumophila*, particularly serogroup 1
- We notify immediately
- Take action to reduce



Culturing for Legionella

- Before performing cultures, be prepared for the result
- Know the limits of the test
- Consider all the elements of increased risk (type of Legionella, transmission potential, and likely host)



Cooling Water Treatment: ASHRAE Position Statement

- "The efficacy of a specific biocide treatment in controlling legionellae can only be determined by testing specifically for the presence of legionellae in the field under actual working conditions". * True or False?

Studies on Biocide Efficacy

- ASHRAE-sponsored research in the U.K.
 - Thomas, WM, et al. Laboratory observations of biocide efficacy against Legionella in model cooling tower systems. 1999. ASHRAE Transactions

Studies on Biocide Efficacy

- Pittsburgh Study
 - McCall, EC, Stout, JE, et al. Efficacy of biocides against biofilm-associated Legionella in a model system. Intern. Water Conf. 1999

Biocide Efficacy: U.K. Study

- Tested in a model cooling tower system
- Biocides tested: Chlorine, bromine, ozone, DBNPA, gluteraldehyde, quaternary amine, Isothiazolin.

Biocide Efficacy: U.K. Study

- Conclusion:
 - The halogenated oxidizing biocides (chlorine, bromine) and ozone were more effective at controlling Legionella growth in the biofilm than the non-oxidizing biocides (DBNPA, gluteraldehyde, quaternary amine, and isothiazolin).

Biocide Efficacy: Pittsburgh Study

- Tested in a model recirculating system
- Sampled Legionella in both planktonic and biofilm phases
- Biocides tested: Chlorine; 1-bromo-3-chloro-5,5 Dimethylhydantoin (BCD); carbamate; gluteraldehyde, quaternary amine, .

Biocide Efficacy: Pittsburgh Study

- Conclusion: Rank order of biocide efficacy (from most to least active)
- Chlorine>BCD>Gluteraldehyde>Carbamate>Quat

Biocide Efficacy and Legionella

- Based on the current data as well as field observations:
 - I would not recommend the use of a quaternary ammonium compound or carbamate as single biocidal agents for the control of Legionella in water systems.

Legionella Disinfection Methods: Potable Water

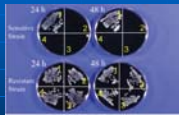
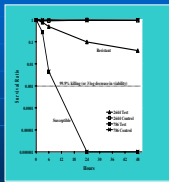
- Copper-silver ionization (continuous).
- Thermal shock treatment (heat & flush).
- Shock chlorination (≥ 10 mg/L residual), may require water tanks to be 20-50 mg/L.
- Continuous supplemental chlorination (2-4 mg/L).
- New Technology - Chlorine Dioxide (ClO_2).
- Point-of-use filtration.

Copper-Silver Ionization

- Copper and silver ions are released from a flow through cell into the hot water system.
- Ions are maintained at
 - Copper: 0.2 ~ 0.4 mg/L; Silver 0.02 ~ 0.04 mg/L
- Ion concentrations are well below US EPA limits for drinking water.



Emergence of Resistance to Copper-silver



Copper-silver Ionization in 2006

- Advantages**
 - Effective against Legionella and other waterborne pathogens
 - Validated efficacy over time and many institutions
 - Applied to the hot water supply only
- Disadvantages**
 - Applied to the hot water supply only
 - Development of resistance over time possible
 - Periodic monitoring for ions (min. quarterly)

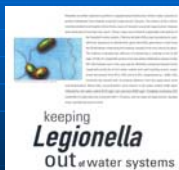
New Technology: Chlorine Dioxide

- Chlorine dioxide (ClO_2) can be generated by an electrolytic method from sodium chlorite (NaClO_2)



Field Study Chlorine Dioxide: An Alternative Disinfection Approach for Legionella Control

- Authors: F.P. Sidari, J.E. Stout, J.M. VanBriesen, V.L. Yu, A.M. Bowman, D. Grub, A. Neuner, M.M. Wagener
- Jan. 24, 2004; J. American Water Works Assoc. 96:111-119



Complete Eradication of Legionella from Hot Distal Sites Required more than 1.75 Years of Chlorine Dioxide Use

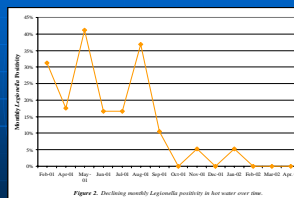


Figure 2. Eliminating monthly Legionella positive hot water over time.

Challenges

Chlorine Dioxide Regulatory Guidelines

Item	EPA Requirement
Maximum Residual Disinfectant Level (MRDL)	0.8 mg/L as Chlorine dioxide ¹
Maximum Residual Disinfectant Level Goal (MRDLG)	0.8 mg/L as Chlorine dioxide ¹
Residual Monitoring	Daily at Entrance ^{2,3}
Maximum Contaminant Level (MCL)	1.0 mg/L as Chlorite ¹
Maximum Contaminant Level Goal (MCLG)	0.08 mg/L as Chlorite ¹
DBP Monitoring	Daily at Entrance, Monthly at 3 locations in distribution system ^{2,3}

¹ National Primary Drinking Water Standard as of January 1, 2002.
² EPA Alternative Disinfectants and Oxidants ManualTM
³ Multiple location sampling required if MRDL or MCL is violated.

Chlorine Dioxide

- Advantages
 - Effective disinfectant against Legionella and other waterborne pathogens
 - Applied to the incoming water supply
- Disadvantages
 - Extended time to achieve reduction in Legionella colonization
 - Monitoring for disinfectant and by-products

Transplant Patients are at the Greatest Risk for Waterborne Infections



Point-of-use Filtration: Possible Applications

- High risk patients-
 - Bone marrow transplant units
 - Solid organ transplant units
 - Hematology/oncology units



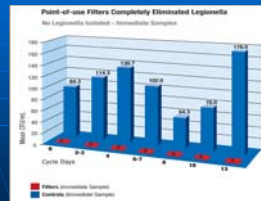
An Absolute Barrier Against Exposure to Waterborne Pathogens

Efficacy of new point-of-use water filter for preventing exposure to Legionella and waterborne bacteria

Hansen J, Griffin SP, Jones J, Dowd PM, Spector R, Sogano DM, Anderson R, Nadeau R, Fildes J, Brumfiel M

Am J Infect Control 2005; 33:S20-25.

Complete Elimination of Legionella



Point-of-use Filters: Conclusions

- System-wide disinfection may not always be the best answer. A targeted approach to disinfection may be more appropriate
- Filtration can be quickly implemented in an outbreak situation and used for a limited time
- High risk areas may require long-term use for maximum risk reduction

Some Things to Think About....



- New Guidance and standards (ASHRAE) for Legionella prevention will affect the way you do business
- Will your approach be Proactive or Reactive?
- Will you have the competent support you will need?
- Be Pro-active - formulate a risk reduction strategy now

My Opinion...Participate in the Process



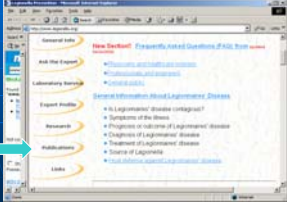
When it Comes to Preventing Illness Due to Waterborne Pathogens (Legionella) – Be Pro-active, not Re-active



Prevention = Multidisciplinary Team

- Microbiology
- Medicine
- Safety & Health
- Engineering!

Informational Website (FAQ's)
www.legionella.org



www.specialpathogenslab.com

412-281-5335

Thank You!

