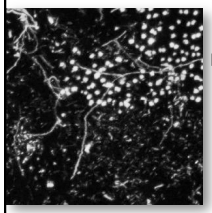
Dental Treatment Water Contamination, Control, and Monitoring

Prof. Raghunath Puttaiah, Texas A&M University, Baylor College of Dentistry

A Webber Training Teleclass

DENTAL TREATMENT WATER CONTAMINATION, CONTROL AND MONITORING



Raghunath Puttaiah, BDS, MPH

Professor - TAMU Baylor College of Dentistry

& Owner - OSHA4Dental Consulting

www.osha4dental.com

Email: drputtaiah@gmail.com

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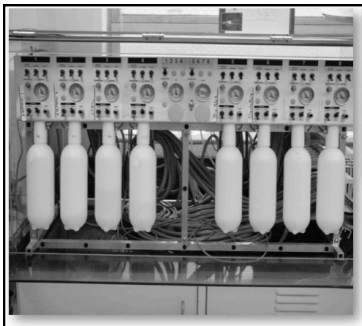
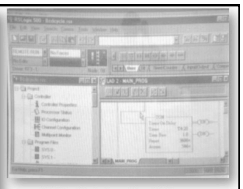
WHAT I DO APART FROM 3.5 DAYS OF CLINICAL TEACHING



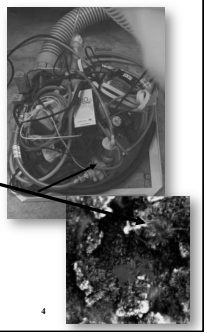


RS Logix Automation Software

Automated Dental Unit Simulation Experimental System

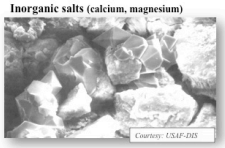
Contamination Levels in Dental Treatment Water

- Tap/Municipal Water has 40 – 400 CFU/mL
- Dental TX Water has heterotrophic counts in excess of 1,000,000 cfu/mL
- Mature biofilms develop in the within a period of 4 weeks
- Microorganisms found in this biofilm could be pathogenic in such high doses
- There is a potential for infection and disease



Types of Contaminants

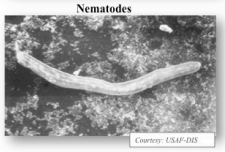
Inorganic salts (calcium, magnesium)



Courtesy: USAF-DIS

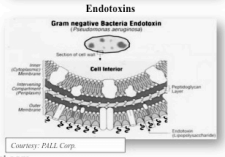
Biofilms, bacteria & fungi

Nematodes



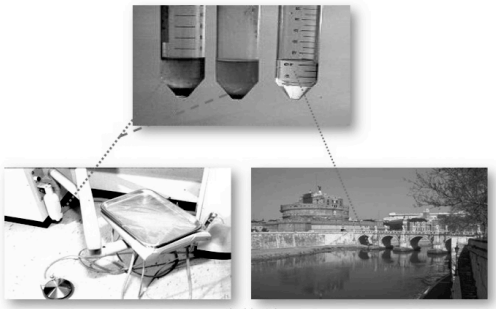
Courtesy: USAF-DIS

Endotoxins



Courtesy: PALL Corp.

Where did these water samples come from?



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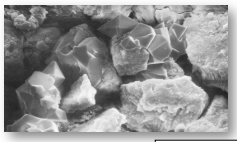
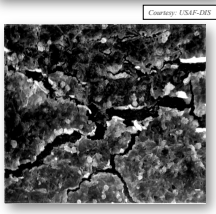
- Salts from municipal water affect repulsive charges of the line against bacterial settlement

- Also cause tarnish, corrosion and blockage of the system



Courtesy: USAF-DIS

- Glycocalyx, macromolecules & bacteria adhere to the inner lumen
- Planktonic organisms (free-floating) adhere to these molecular insertions
- Form layers and a mature matrix in weeks with intricate lattice-work
- Thickness of biofilm 30-100 microns
- Chunks break up contaminating water



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Salts in the municipal water

1. Distiller still with heating element
2. Still with salts after distilling about 450 gallons of municipal water
3. About 450 gallons of municipal water in Dallas, showed about 300 grams of salts

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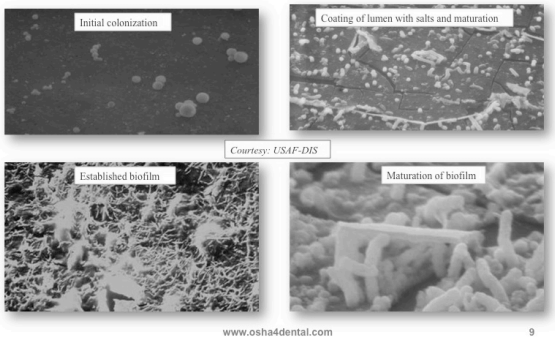
Biofilm formation



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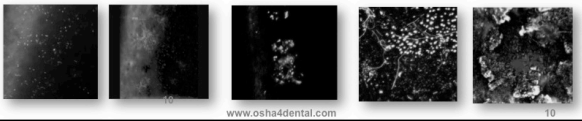
This is how a biofilm looks in the dental unit waterlines

Scanning Laser Confocal Microscopy

Week 3	Week 8	Week 10	Week 26	>10 years



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Microbes , Morbidity & High Risk Patients

Pseudomonas	= Super-infections
Mycobacterium	= Lung infections
Legionella	= Lung and gut infection
Moraxella	= Bacterial Endocarditis
Fungi	= Fungal infections

Possible high risk patients

Neutropenic Patients
Post Radiotherapy
Uncontrolled Diabetes
Spina Bifida
Patients with certain Cancers
Patients with other Chronic Illnesses
Chronic nutritional deficiencies

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Evidence of disease risk

Fotos et. al; JDR 1985, 64(12):1382 - 1385.

20% of students & employees in dental settings showed higher IgG antibodies to *Legionella* than Controls [1]

- Reinthaler et. al; JDR 1988, 67:942 - 943.

High prevalence (50%) of antibodies to Legionella in dentists [2]

Oppenheim et. al; Epidemiol & Infect 1987, 99:159-166.

Aerosols from dental units found to be the source of sub-clinical infection with *L. pneumophila* in a dental school [3]

Atlas et. al; Appl & Env. Microbiol 1995; 61(4): 1208-1213.

-68% of DUW samples from 28 dental clinics had Legionella
-61% of potable water from domestic/institutional faucets had at least one form of Legionella [4]

But we waited for dead bodies.....

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Legionnaire's Disease & Pontiac Fever

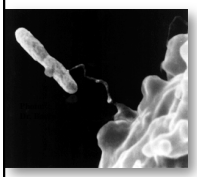
- 1976, Philadelphia, Veterans of the American Legion Meet. 182 Cases of pneumonia and 29 deaths
- 1977 Causative microorganism identified and duly named *Legionella pneumophila*

Bellevue-Stratford Hotel
Image Source- Wikimedia

- **Two Clinical Conditions --**Legionnaires' disease & Pontiac Fever
- Signs & Symptoms of Legionnaires' disease--Fever, chills, cough, muscle aches, headache, tiredness, loss of appetite, ataxia, diarrhea, vomiting, relative bradycardia in spite of fever. Impaired Renal Function, Liver Function, Electrolyte Imbalance and Hyponatremia. X-rays show pneumonia
- Incubation period 2-10 days after exposure
- Difficult to differentiate from other pneumonias or influenza based on clinical findings alone
- Signs and Symptoms of Pontiac Fever-- Fever and muscle aches without pneumonia with recovery in <5 days without any Tx
- Incubation period is a few hours to 2 days after exposure
- Both conditions are common in the old, smokers and immunocompromised people

…….so it happened

Death due to Legionella pneumophila infection from dental unit water system



- **Italy**: February, 2011, an 82-year-old woman admitted to hospital due to fever and respiratory distress
- Radiography showed several areas of lung consolidation

Reference:

Pneumonia associated with a dental unit waterline. *Maria Luisa Ricci, Stefano Fontana, Federica Pinci, Emanuela Fiumana, Maria Federica Pedna, Paolo Farolfi , Maria Antonietta Bucci Sabattini, Maria Scaturro. Lancet 2012; 379: 684*

Death due to Legionella pneumophila infection from dental unit water system

- Legionnaires' disease was promptly diagnosed by *Legionella pneumophila urinary antigen test* and bronchial aspirate for microbiological examination
- Patient developed fulminant and irreversible septic shock and died 2 days later
- Investigation to find the source of *L pneumophila* infection revealed Dental Clinic Water Samples showed positive *for L.. pneumophila* ((6.2X10^4 CFU/mL)

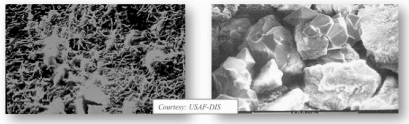
Death due to Legionella pneumophila infection from dental unit water system

- Patient's domestic water samples negative
- Three different typing methods showed the clonal relation between the clinical and environmental strains.

So …. We now have proof of a death

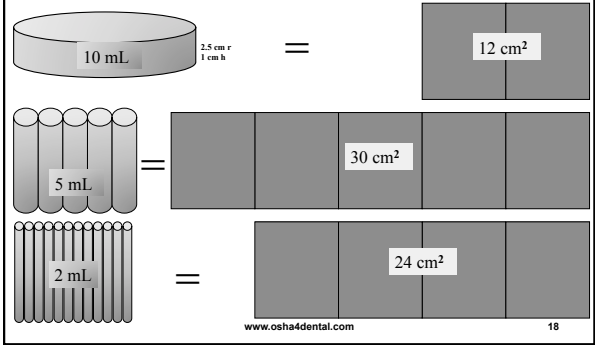
Factors associated with contamination

-Long periods of stagnation
Cumulative use per day ≤ 2 hours
Overnight stagnation > 12 hours
-Nutrient content of source water for microbial survival
Minerals
Organic matter
-Mineral content & hardness of water assist in coating of lines



Courtesy: USAF-DIS

High Surface to volume ratio: ***Smaller the diameter of line, more relative surface available per volume of water & vice-versa***



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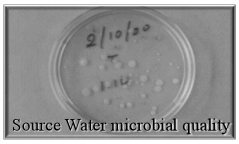
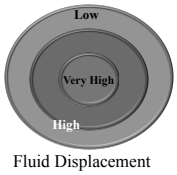
- **Low flow rate**
- **Fluid dynamics (laminar flow)**
  Lesser resistance in the center of the lumen therefore biofilm not disrupted by flushing
- **Microbial quality of source water**



Water usage

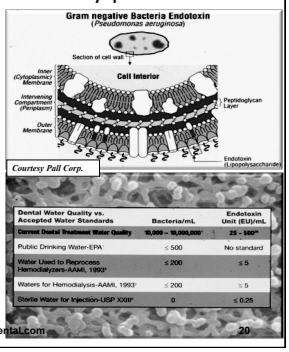


Fluid Displacement

Endotoxins & Disinfection-by-products

- ***Bacteria die, endotoxins are released and have a potential for a pyrogenic response (inflammation)**
  - Amounts of endotoxins found in tap water ranges from 10 to 20 EU/mL
  - The first flush with water after cleaning lines with a Hypochlorite shows >500 EU/mL
  - Constantly present bleach (2.5-5ppm) in lines with biofilms shows about 50-100 EU/mL
  - AAMI standards for Renal Dialysate < 5 EU/mL

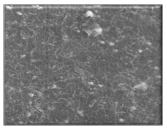
*Puttaiah, IADR 1998, Abstract.



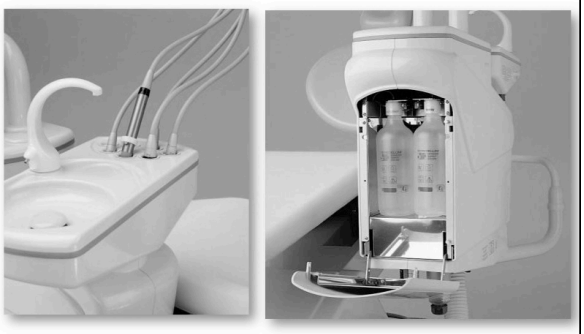
*Trihalomethanes as DBPs

- **Occur in water due to the action of NaOCl on Biofilms (organic)**
- **EPA's exposure limits <100 ppb**
- **Proposed EPA exposure limit <80ppb**
- **DUWL with mature biofilms when cleaned with 5000 ppm bleach show >8000 ppb**
- **In the presence of mature biofilms if 3-4 ppm bleach is used, we can get in excess of 500 ppb of THM**
- **THMs are suspected carcinogens**
- **Therefore, use of bleach is questioned**

+



*Puttaiah et al, OSAP 1999, Abstract – measurements of disinfection-by-products when bleach is used to clean contaminated dental water systems



Castellini – Autosteril = the best system

Dental Treatment Water or Dental Irrigants

- If periodic cleaning agent is used…

  dental treatment water must--
  - Be sterile
  - Be filtered
  - Be boiled
  - Be pasteurized
  - Be distilled
  - Have low mineral content
  - Have low endotoxin content

- If periodic cleaning agent is used…

  irrigant should--
  - Be biocompatible low grade germicide
  - Be compatible with equipment
  - Be compatible with composite bonding to enamel and dentin
  - Be a preservative and control contamination
  - **NOT BE BLEACH**

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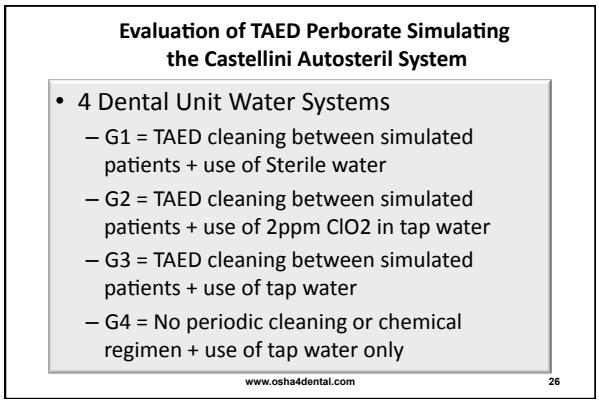

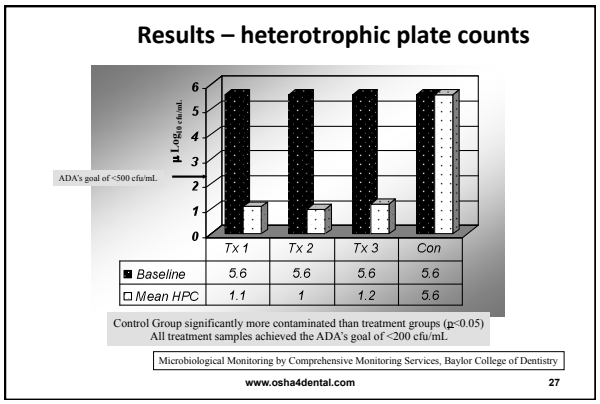

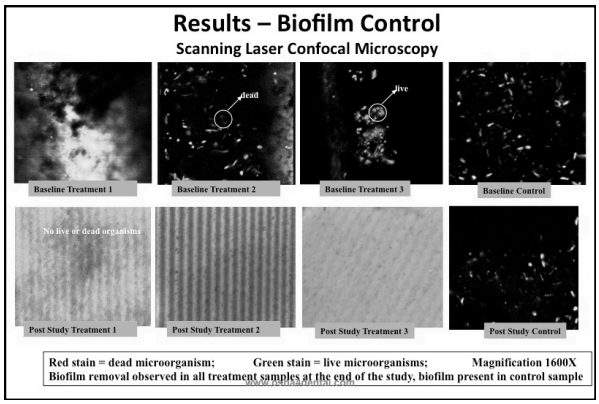

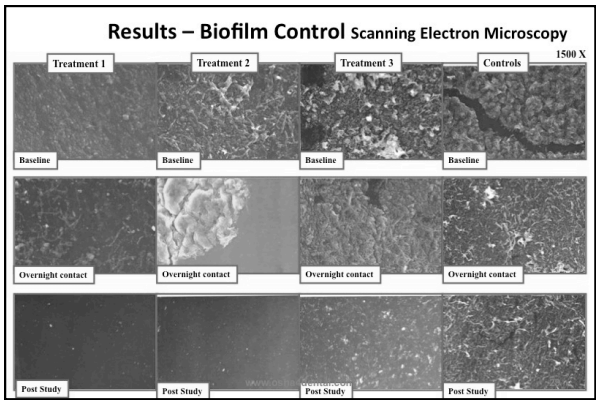

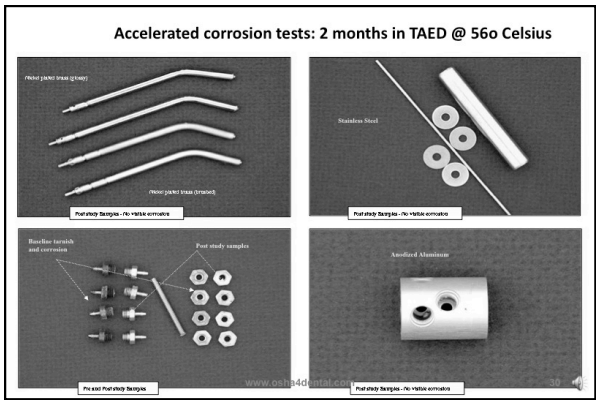

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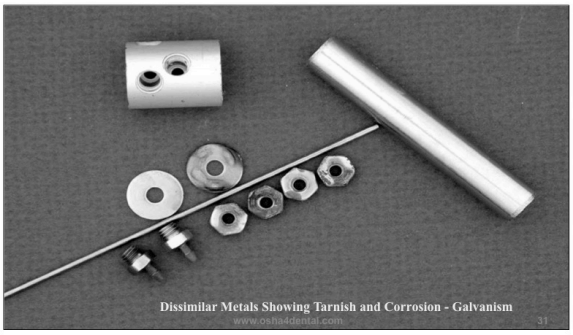
Accelerated corrosion tests: 2 months in TAED @ 56o Celsius



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Conclusion

- Reduces workload for employees
- Removes Biofilms
- Colony counts almost ZERO
- Chemical very compatible with the Autosteril System
- Exceeds CDC's and ADA's requirements
- May be a good alternative in areas where the US regulations are not applicable for Surgical Water/ Application

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Some items in the US & Other Markets

•Registration of the chemicals with agencies such as the United States Environmental Protection Agency (US-EPA) and clearance of the United States Food and Drug Administration (US-FDA) or agencies in the European Union (EU) for safety issues or with Regulatory Agencies in India
•Biofilms and other deposit removal efficacy
•Proven Compatibility with metals, plastics and rubbers in the water system
•Proven evidence of easy removal of periodic cleaning agent from the water system
•Biocompatibility of periodic cleaning agent and irrigant with humans
•Should not produce dangerous disinfection-by-products such as trihalomethanes
•Proven compatibility of irrigant with composites bonding to enamel and dentin

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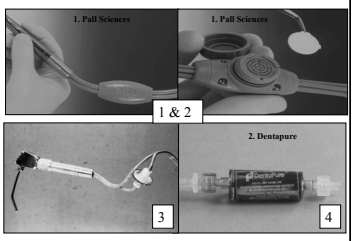
Some methods of microbial control

- **Physical Methods**
  1. **Single-patient-use (0.22 micron) with endotoxin retention capability**
  2. **Daily change Point-of-use (0.22 micron) filters**
  3. **Weekly change point-of-use (0.22 micron) filters**
  4. **Weekly change point-of-use filter cartridges with iodinated resin**



1. Puttaiah et al, A Multi-Group Longitudinal Study of Dental Unit Waterline Contamination, IADR 1996, Abstract
2. Puttaiah et al, Effects of Constantly Present Low Grade Iodine on Dental Unit Waterline Biofilm and Planktonic Contamination. 1999 OSAP , Abstract

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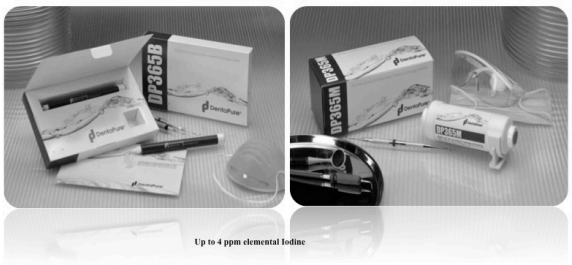
Constantly Present Germicide – DentaPure



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Some items in the US & Other Markets

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Cleaning Lines – One Method

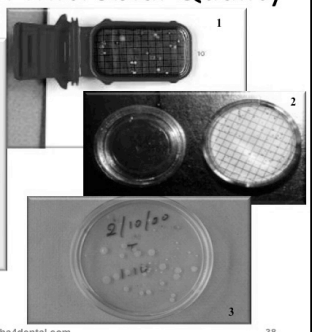
Monitoring of Microbial Quality

Screening *Vs*. Diagnostic tests

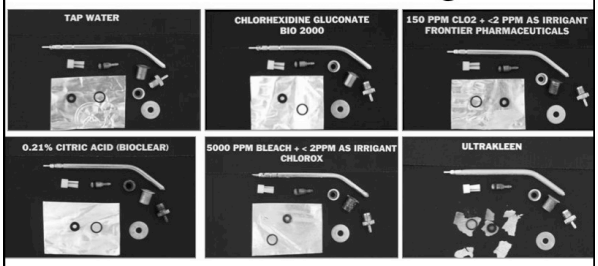
1. **HPC Water Samplers (Millipore Inc.)**
2. **Aquasafe Samplers (Pall Corp.)**
3. **R2A Agar is the Gold Standard**

The error rate of HPC samplers was >40% When compared to R2A (Puttaiah, et al, AADR 2001; Abstract JDR)

Significant decrease in detection by HPC and Aquasafe in comparison to R2A (Puttaiah, et al, AADR 2002; Abstract JDR)



Corrosive Nature of Irrigants



Irrigant Compatibility with Bonding

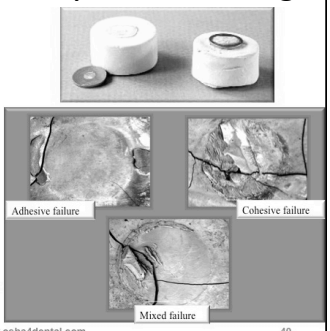
BioClear

- CloSYS II
- Oris CHX
- Tap water
- Bio 2000
- DioxiClear™
- Dentapure

No significant difference between bond strength between Txs, alpha>0.05.

Puttaiah, Griggs et al, in preparation.

Other studies have shown varying degrees of effects but no control of bias and blinding



Goals & Standards ??

- **The American Dental Association stated in 1995 that its Goals for year 2000 was that the dental treatment water to be <200 CFU/mL of heterotrophic mesophilic organisms.***
- **What are the reasons the ADA and the BDA have given for not making it a recommendation**
  - **No mortality associated with the high levels of microbial contamination?**
  - **Do we wait for mortality and morbidity to drive all policies???**
  - **Do the microorganism found in dental unit water systems have the potential for causing infections and death among dental patients?**
  - **What categories of dental patients do we have based on susceptibility for infection and death?**

Current CDC's recommendation is <500 cfu/mL

*Based on the Renal Dialysate Standards

Coming Soon

27 November ***(South Pacific Teleclass)***
PROMOTING HANDWASHING WITH SOAP IN THE INDIGENOUS COMMUNITY CONTEXT
Liz McDonald, Menzies School of Health Research, Australia

01 December RELEASE OF 2014 TELECLASS SCHEDULE

04 December ***(FREE - WHO Teleclass - Europe)***
CONTROL OF MULTI-DRUG RESISTANT ORGANISMS IN THE NURSING HOME SETTING
Prof. Andreas Voss, Nijmegen University, Netherlands

12 December LYME DISEASE: KNOWLEDGE, BELIEFS, AND PRACTICES OF PHYSICIANS IN A LOW ENDEMIC AREA
Dr. Bonnie Henry, British Columbia Centre for Disease Control

19 December IS THERE VALIDITY TO VRE TESTING AND SCREENING?
Dr. Michelle Alpha, University of Winnipeg

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