

How Should We Clean 21st Century Hospitals?

Dr. Stephanie Dancer, NHS Scotland
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Hosted by Martin Kiernan
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www.webbertraining.com November 3, 2011

Properties of hospital pathogens

	Survival time	Infectious dose
MRSA	7 days to 7 months	4 cfu's
Acinetobacter	3 days to 5 months	250 cfu's
C.difficile	5 months	7 spores
VRE	5 days to 4 months	<10 ³ cfu's
Norovirus	8 hours to 7 days	10-100 virions

Kramer, BMC Infect Dis, 2006; Dancer SJ, LID 2008; Chiang, Crit Care Med 2009; Wilcox M, 2010; Larson, Lancet 1978; Kjerulf et al, APMS 1998

Where are the pathogens in a hospital?

Hayden et al, SHEA 2004

Frequently touched surfaces!

Carling et al, JHI 2010

Do HCWs acquire pathogens from surfaces or patients?

A

Category	Sub-category	Result (%)
Skin cultures	Skin (any)	~45
	Abdomen	~18
	Oral	~18
	Arm	~18
Environmental cultures	Environment (any)	~45
	Call button	~20
	Bed rail	~18
	Table	~18

B

Category	Sub-category	Mean CFU/handprint
Skin cultures	Skin (any)	~10
	Abdomen	~18
	Oral	~12
	Arm	~8
Environmental cultures	Environment (any)	~5
	Call button	~8
	Bed rail	~6
	Table	~6

Hand contamination with MRSA was similar after contact with patients' skin and frequently touched environmental surfaces in patient rooms

Stiefel et al, ICHE 2011

Every surface you touch...

Fingertips from 500 HCWs were MRSA positive:

- 6% after clinical contact
- 7% after contact with the environment**
- 4% after no specific contact

MRSA was recovered after using:

- alcohol rub (3%)
- chlorhexidine (6%)
- soap & water (3%)

and on 5% occasions with NO hand hygiene!

Creamer et al, JHI, 2010

HCWs touch environmental sites all the time

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What's on YOUR hands??!

Even if you always keep your hands clean, any benefits from hand hygiene are eroded if there is MRSA or C.difficile on the very next surface you touch

Bobulsky G et al, CID 2007; Farr et al, LID 2001

A Room with a View

40x30 min covert observation periods following entries into one isolation room

Sequential hand-touch recording strategy

Staff Member	Near Touch Sites			Clinical Equipment			Far Touch Sites		
	Alcohol Gel Before Entry [Y/N]			Patient Contact [Y/N]			Alcohol Gel After Leaving [Y/N]		
Junior Doctor									
Senior Doctor									
Staff Nurse									
Auxiliary Nurse									
Cleaner									
Caterer									
Pharmacist									
Relative									

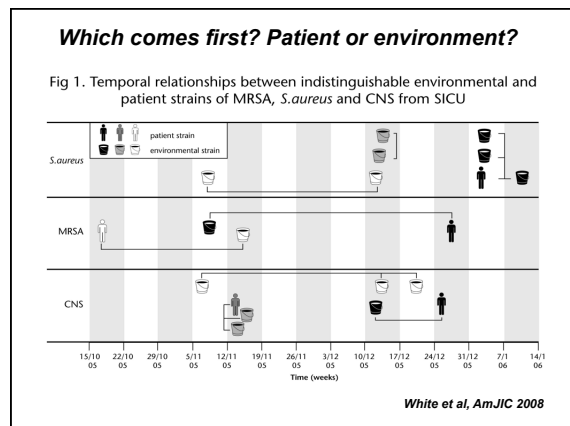
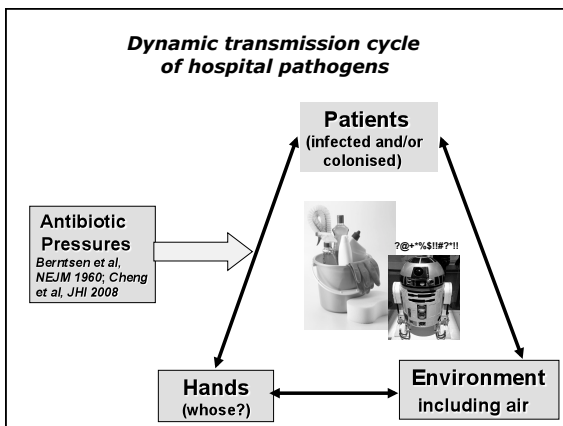
Audit of sequential hand-touch... Who touches what?

Overall compliance with hand hygiene among 154 staff before and after entry was **25%**

Over half (58%) of 77 clinical staff touched the patient;
Most frequently handled items inside room: **IV drip & BP stand**
Outside the room: **computer, notes trolley and telephone**

Since hand hygiene compliance is so low, could we target high risk sites for cleaning?
.....who cleans these?

Smith et al, ECCMID 2011



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Could patients' hands constitute a missing link?



Banfield & Kerr, J Hosp Infect 2005

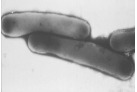
Cleaning patients' hands reduces MRSA infection rates
Gagne et al, J Hosp Infect 2010

Role of the air?



NHS Greater Glasgow & Clyde

**Just hanging around....
airborne spores**



Spore length	Terminal velocity (mm/s)	Fallout time (hours) from a height of:			
		1 m	2 m	3 m	4 m
0.79 mm ^a	0.02	13.9	27.8	37.4	55.6
1.04 mm ^b	0.035	7.9	15.9	19.8	31.7
1.14 mm ^b	0.04	6.9	13.9	17.4	27.8
1.42 mm ^b	0.066	4.2	8.4	10.5	16.8
1.99 mm ^c	0.13	2.1	4.3	6.4	8.5

^a Shortest overall spore length
^b Average spore lengths for 3 tested strains
^c Longest overall spore length

Snelling et al, ICHE 2010

How well is environmental cleaning being done?




Are shiny floors enough ?

Carling PC, 2010

How well are hand-touch sites cleaned?

Fluorescent gel placed on sites in side-rooms
After patient discharge, a site is considered cleaned if the fluorescent material is removed or disrupted



Ecoblab®

'Although 40% sites were cleaned properly, they tended to be the more traditional sites (toilets and sinks) whereas sites such as telephones, doorknobs and other hand-touch surfaces were scarcely cleaned at all'

Carling et al, Am J Infect Control, 2006

How clean are hospital surfaces?

82-91% Visually clean
10-24% ATP clean
30-45% Microbiologically clean

What is clean?
"what an individual thinks it is"

We should not define cleanliness without indicating how we would assess it

Griffith CJ et al, J Hosp Infect 2000

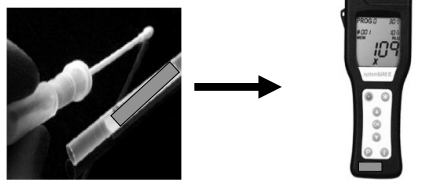
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Surface evaluation using ATP bioluminescence

Swab surface → luciferase tagging of ATP → Hand held luminometer



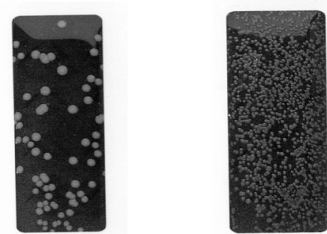
Used in the commercial food preparation industry to evaluate surface cleaning before reuse and as an educational tool for more than 30 years

ATP values for sites on medical (M) & surgical (S) wards

Site		Before	After	Site Mean ATP Before	Site Mean ATP After
Locker (M)	Range	15-316	17-148	120	69
	Mean	106	47		
Locker (S)	Range	7-325	5-208	105	131
	Mean	134	91		
L Bed (M)	Range	4-243	4-1512	181	309
	Mean	106	206		
L Bed (S)	Range	4-181	32-115	132	57
	Mean	103	56		
O/B Table (M)	Range	28-625	13-75	181	309
	Mean	116	36		
O/B Table (S)	Range	33-550	55-3846	132	57
	Mean	246	581		
R Bed (M)	Range	3-409	3-200	132	57
	Mean	145	60		
R Bed (S)	Range	0-266	16-128	132	57
	Mean	118	54		

Mulvey et al, JHI 2011

Would microbiological standards help?



5 cfu/cm² 45 cfu/cm²

Slide courtesy of Chris Griffith; Dancer, JHI 2004

Microbiological standards for surface hygiene in hospitals


Standard 1
There should be <1cfu/cm² pathogen (MRSA; C.difficile; VRE; etc) in the clinical environment

Standard 2
The Aerobic Colony Count (ACC) or total microbial growth level from a hand contact surface should be <5 cfu/cm²


These standards are based upon food industry counts as applied to food preparation surfaces but could be utilised for frequent hand touch surfaces in hospitals

Dancer S, J Hosp Infect 2004

Application of standards on a ward




S.aureus & MRSA prefer lockers, overbed tables and beds; finding these at a site was significantly associated with higher aerobic colony counts from that site (p=0.001)



Dancer SJ et al, IJEHR 2008

Application of standards on ICU



25% of 200 samples failed the standards, mostly hand-touch sites

Hygiene fails were associated with bed occupancy and incidence of ICU-acquired infection

Hygiene standards reflect patient activity and provide a means to risk manage infection


White et al, Am.JIC, 2008

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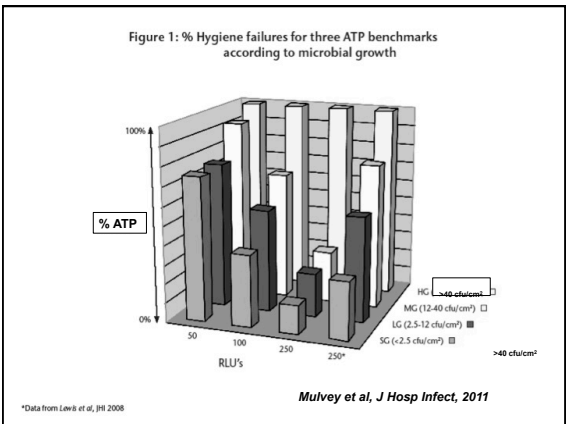
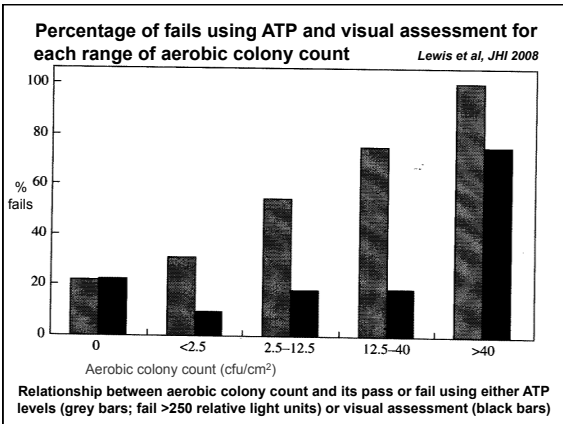
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Is there a relationship between microbiological standards and ATP levels from surfaces?


Measuring ATP levels can tell you how good the general cleaning is AND it encourages cleaners to improve their cleaning efficiency (Boyce et al, ICHE 2009) ...



.....but there is no point routinely measuring ATP levels from hospital surfaces if there isn't going to be any benefit for patients



What is the evidence for cleaning as a viable control mechanism for MRSA?

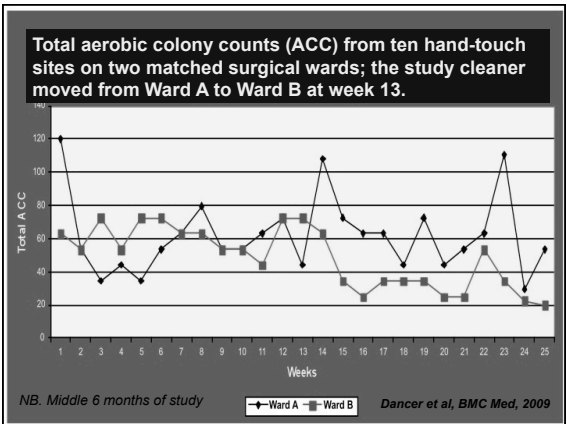


We introduced one extra cleaner into two wards from Monday to Friday, with each ward receiving extra detergent-based cleaning for six months in a prospective cross-over design

Ten hand-touch sites on both wards were screened weekly and patients were monitored for MRSA infection throughout the year-long study

Patient and environmental MRSA isolates were characterized using DNA finger-printing

BBC website, 2008 Dancer et al, BMC Med 2009



What did we find?

One extra cleaner was responsible for a 33% reduction in colony counts on hand-touch sites; and 27% reduction in new MRSA infections, despite busier wards and more MRSA patient-days

Adjusting for MRSA patient-days and based upon 9 new MRSA infections found during control periods, we expected 13 new infections during enhanced cleaning periods rather than the four that actually occurred

DNA fingerprinting confirmed indistinguishable strains from both hand-touch sites and patients - some of these were isolated months apart

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Was the extra cleaning cost effective?

- The study cleaner earned £12,320 per annum
- Consumables were £1,100
- Average cost of one hospital-acquired MRSA surgical site infection at least £9,000
- Enhanced cleaning spared 5-9 patients MRSA
- The hospital thus saved £45,000-£81,000 minus the costs of cleaners and consumables
- Overall savings estimated as **£31,600 - £67,600** for two wards over a 1 year period

Dancer et al, BMC Med 2009

More cleaning helped terminate this MRSA outbreak

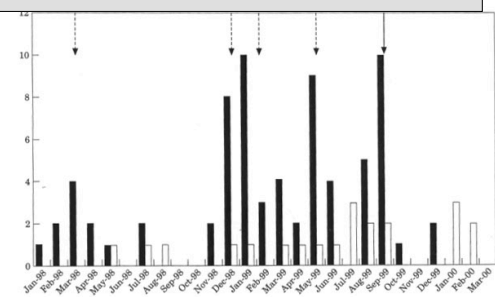
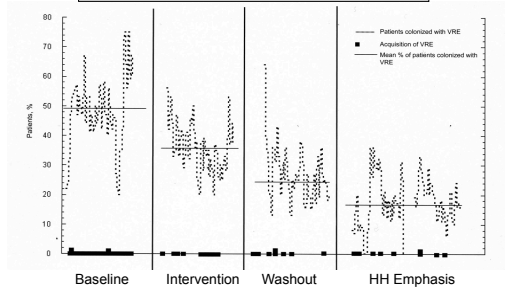


Figure 1 Numbers of patients with newly acquired MRSA on the male surgical ward from January 1998 to end March 2000. Dark columns indicate the outbreak MRSA; Light columns indicate other miscellaneous strains; ---> Outbreak control measures; --> Intervention.

Rampling et al, J Hosp Infect, 2001

Cleaning works for VRE as well



- decreased surface contamination with VRE;
- less frequent VRE contaminated HCW hands
- a significant reduction in VRE cross-transmission

Hayden et al, CID 2006

Disinfectants vs Detergents

Disinfectants do not degrade
They are expensive & toxic
Incite mutation and resistance



Are there less toxic alternatives?

Microfibre: recontamination; decontamination

Moore & Griffith, JHI 2006; Wren et al, JHI 2008; Bergen et al, JHI 2009

•Steam: operator dependent; electrical items; aerosol potential

Meunier et al, Pathol Biol 2008; Griffith & Dancer, JHI 2009

•Hydrogen peroxide: expensive; confined areas; not fabrics

Shapey et al, JHI 2008

•UV light: expensive; hidden corners; inadequate for *C. difficile* spores

Havill et al, SHEA 2010; Maclean et al, JHI 2010



How good is microfibre compared with other cleaning cloths in the hospital?

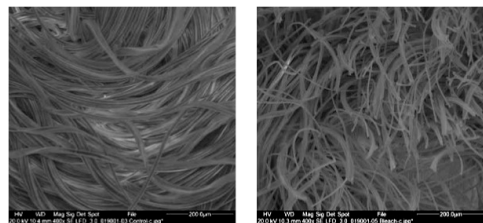
The cleaning effect of microfibre cloths was compared against cotton cloths after reprocessing both types of cloth 10 and 20 times

Microfibre cloths were better when new, but after being reprocessed 20 times, cotton cloths were the best; tests used *S. aureus* ($p=0.0334$) and *E. coli* ($p=0.0014$).

Diab-Elschahawi et al, AMJIC 2010

What does bleach do to microfibre?

Scanning electron micrographs of ultra microfibre (UMF) cloths treated for 16 h. The UMF fibres are intact after exposure to water but the fibres have been severed after exposure to Chlor-Clean. Magnification: $\times 400$.



Giant VA et al, J Hosp Infect 2010

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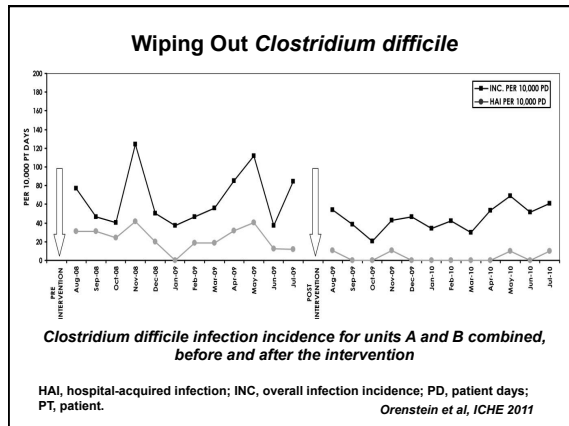
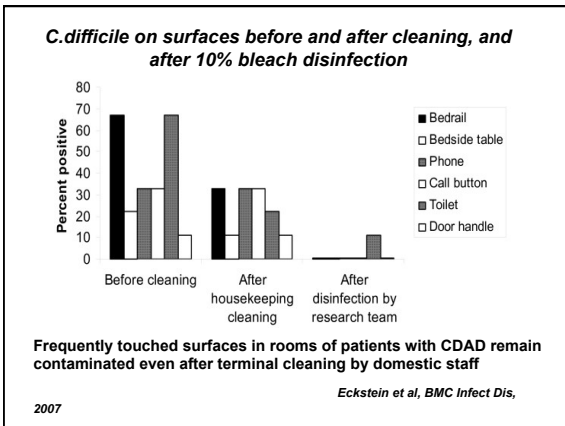
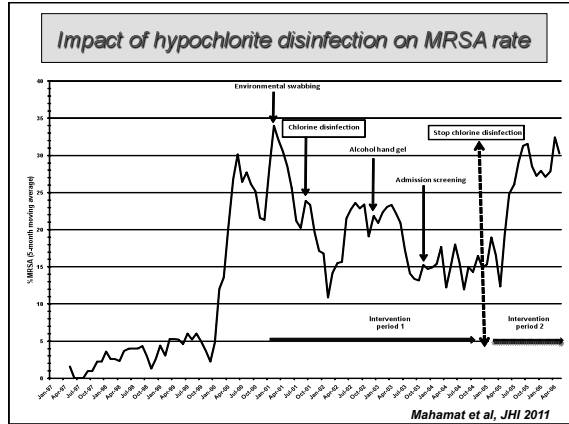
Randomized cross-over cleaning study on two London ICU's

- Disinfectant and microfibre used for enhanced cleaning
- High risk sites cleaned twice per day
- Less MRSA in the environment
- Less MRSA on doctors' hands

No effect on patient MRSA acquisition!

Too much disinfectant used during routine periods?
Confounded by people-traffic and airborne spread?
Hawthorne effect by staff?
Length of stay?

*Wilson et al Crit Care Med 2011
Dancer et al Crit Care Med 2011*



Is the frequency of cleaning important?

Contact plates from patient locker surface
Left to right: Pre clean, 1 hour, 2 hour, 3 hour assessment

Mike Rollins, Osprey

MRSA rapidly recontaminates high-touch sites after cleaning

Hardy KJ et al, JHI 2007

MRSA contamination of ICU environmental sites before and after cleaning

Sites positive for MRSA before cleaning	Sampling times at which MRSA was recovered
Infusion pumps; syringe-driver	2, 3, 4, 5, 6 and 7 hours
Handles; bedside stand; cot sides; computer	7 hours
Cot sides	2 hours
Pumps; syringe-driver; cot sides	3 hours
Bench top; ventilator; cot sides	1 and 5 hours
MRSA negative sites	5 hours

How important is the frequency of cleaning?

Aldeyab et al, ICHE 2009

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Do wipes reduce bacterial counts when swiped across plastic surfaces?

Swiping plastic surfaces with any type of moist wipe decreases the bacterial burden

When surfaces are swiped 3 or more times, a detergent wipe is *just as effective* as disinfectant wipes. However, if a health care worker cleans a plastic object only once, then a disinfectant wipe should be used

Berendt et al, AmJIC 2011

Beware! If you keep using the same wipe again, it will accumulate microbes

Cheng et al, AmJIC 2011

Cleaning.... near-patient hand-touch sites

(a) venetian blind cord
(b) ward door
(c) box
(d) curtain

Vickery et al, JHI 2011

New disinfectants on the block

Chemzyme Plus
A soup of *Bacillus subtilis*
A new study has found a cleaning liquid containing good bacteria reduced 'bad' bacteria by 1,000-fold compared with standard cleaning techniques

Aqualution
Electrolysed water
Also eradicates 'bad' bacteria with hypochlorous acid as active ingredient; non-toxic

Antimicrobial surfaces

- Resist microbial adhesion
Polyethylene glycol;
Biomimetic polymers;
Diamond-like carbon films
- Antimicrobial surfaces
Biocide-releasing (Triclosan, Silver, Copper, Bacteriophage);
Microbicidal on contact (Polycationic surfaces);
Light-activated (Photosensitive material – titanium dioxide)
- Nanocoating (nanotubes plus lysostaphin)

Page K et al, J Materials Chemistry 2009

Are all surfaces equal?

'...antimicrobial coatings must not undermine the success of traditional hygiene methods and neither should conventional cleaning and hygiene practices be relaxed if antimicrobial coatings are employed'

Child T, www.allbusiness.com 2005

Copper surfaces in rooms in intensive-care units reduced the amount of bacteria by 97% and the rate of hospital-acquired infections by 41%

Schmidt et al, ICAAC 2011

Survival of MRSA on silicone elastomer surfaces exposed to 28-W fluorescent light

Bars represent mean number of MRSA recovered:

A. after a 24-hour incubation
B. after a 6-hour incubation

expressed as a percentage of initial MRSA inoculum at time zero

Ismail et al, ICHE 2011

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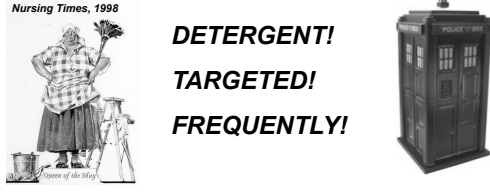
Just a quick blast...



The efficacy of any cleaning/disinfectant agent tested is dependent on physical action....

Alfa MJ et al, BMC Infect Dis 2010

Cleaning in the 21st century: what's best?




**DETERGENT!
TARGETED!
FREQUENTLY!**

In some situations we still need disinfectants, preferably non-toxic; we should find the evidence for soap and water first, before powerful disinfectants destroy our environment

Dancer S.J, EJCMI 2011

Thank you!



NB. No relevant disclosures

COMING SOON ...

- 10 November 11 **Infection Prevention Challenges in Home Care**
Speaker: Mary McGoldrick, Home Health System Inc.
- 17 November 11 **Overview of the New HICPAC Norovirus Guideline**
Speaker: Dr. Taranisia MacCannell, Centers for Disease Control, Atlanta
Sponsor: Virox Technologies Inc. (www.virox.com)
- 01 December 11 **Strategies for Improving Hand Hygiene Compliance in the ICU**
Speaker: Dr. Alexandre R. Marra, Hospital Israelita Albert Einstein, Brazil
Sponsor: Deb Ltd (www.debgroup.com)
- 07 December 11 (Free WHO Teleclass) **Best Practice for Cleaning, Disinfection, and Sterilization in Healthcare**
Speaker: Prof. William Rutala, University of North Carolina
Sponsor: World Health Organization First Global Patient Safety
Challenge: Clean Care is Safer Care (www.who.int/gpsc/en)
- 15 December 11 **Surgical Implants Being Reprocessed: Pandora's Surgery Box is Opened!**
Speaker: Dr. Michelle Alfa, Diagnostic Services of Manitoba

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Coming December 1, 2011
2012 Teleclass Schedule

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