

Industrial Hygiene Innovations in Infection Control

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**ILLINOIS STATE
UNIVERSITY**
Illinois' first public university

What is Industrial Hygiene?

- Anticipation
- Recognition
- Evaluation
- Control

Occupational and Environmental Hazards

Anticipation

- Soaring patient infection rates
- The rise of Multi Drug Resistant Organisms (MDROs)
- Rising costs (penalties) associated with Hospital Acquired Infections (HAIs)
- Workers exposed to and becoming ill from infectious agents.

Recognition

- 13% world's hospital populations get HAIs (WHO, 2006)
- 98,987 HAI related US deaths annually (Klebens, 2007)
- 1.3% - 20% patients have *Clostridium difficile* (APIC, 2008)(Gould, 2010) 72.5% of those HAIs (APIC, 2008)
- In Quebec, 5.7% attributable deaths from HAI C. diff. (Gravel, 2009)
- C. diff. costs the US \$32 million per year (APIC, 2008)

SARS and Healthcare Workers

- 774 deaths/>8,000 SARS cases worldwide (~9%),
- Low infectivity, high severity,
- 44 deaths/375 cases(~12% in Toronto),
- 42% of SARS cases were healthcare workers Toronto (57% Vietnam) (Booth),
- Worker infection rate was directly proportional to patient illness severity and time spent in their room.

SARS Hospital Management Shortcomings

- Failure to track patient contact history,
- Lack of healthcare worker surveillance,
- Failure of ventilation systems and personal protective equipment,
- Failure to track visitor contacts,
- Poor communications and preparedness
 - Recognition of disease, understanding disease, inability to prevent spread.

Work Related Attributable Death

(Hamalainen, 2011)

Major Causes of Work Related Death Worldwide		
Attributable Cause %	Hamalainen, 2011	Takala 2014
Cancer	25	32
Circulatory Diseases	21	23
Communicable Diseases	28	17
Accidents	---	18

Evaluation

- Surfaces
 - C. diff. shown to contaminate 27% samples from environmental surfaces (Dubberke, 2007)
- People
 - Patients nares and skin are a significant source of MRSA cross contamination (Boyce, 2004)
 - Many contaminations come from the patients themselves (Duckro, 2005)
 - Many agents can live for several days/weeks/months on environmental surfaces
- Equipment
 - Sterile surgical equipment, ventilators, catheters, Ivs (Tosh, 2011) (Cefai, 1990)(Castle, 1978)
- Air
 - Outdoor supplies, recirculated systems, disinfection and filtration.

Table 1: Persistence of clinically relevant bacteria on dry inanimate surfaces.

Type of bacterium	Duration of persistence (range)
<i>Acinetobacter</i> spp.	3 days to 5 months
<i>Bordetella pertussis</i>	3 – 5 days
<i>Campylobacter jejuni</i>	up to 6 days
<i>Clostridium difficile</i> (spores)	5 months
<i>Chlamydia pneumoniae</i> , <i>C. trachomatis</i>	≤ 30 hours
<i>Chlamydia psittaci</i>	15 days
<i>Corynebacterium diphtheriae</i>	7 days – 6 months
<i>Corynebacterium pseudotuberculosis</i>	1–8 days
<i>Escherichia coli</i>	1.5 hours – 16 months
<i>Enterococcus</i> spp. including VRE and VSE	5 days – 4 months
<i>Haemophilus influenzae</i>	12 days
<i>Helicobacter pylori</i>	≤ 90 minutes
<i>Klebsiella</i> spp.	2 hours to > 30 months
<i>Listeria</i> spp.	1 day – months
<i>Mycobacterium bovis</i>	> 2 months
<i>Mycobacterium tuberculosis</i>	1 day – 4 months
<i>Neisseria gonorrhoeae</i>	1 – 3 days
<i>Proteus vulgaris</i>	1 – 2 days
<i>Pseudomonas aeruginosa</i>	6 hours – 16 months; on dry floor: 5 weeks
<i>Salmonella typhi</i>	6 hours – 4 weeks
<i>Salmonella typhimurium</i>	10 days – 4.2 years
<i>Salmonella</i> spp.	1 day
<i>Serratia marcescens</i>	3 days – 2 months; on dry floor: 5 weeks
<i>Shigella</i> spp.	2 days – 5 months
<i>Staphylococcus aureus</i> , including MRSA	7 days – 7 months

(Kramer, 2006)

Surface Monitoring

Contact Plates



SURFACE SAMPLING FOR BIOLOGICAL CONTAMINANTS

- A swab or filter wetted with sterile water or wash solution is used to wipe a specified area.
- Typically, the swab is then used to inoculate a culture plate.
- SKC offers a sterile swab kit with swabs in transport tubes and with plastic templates.

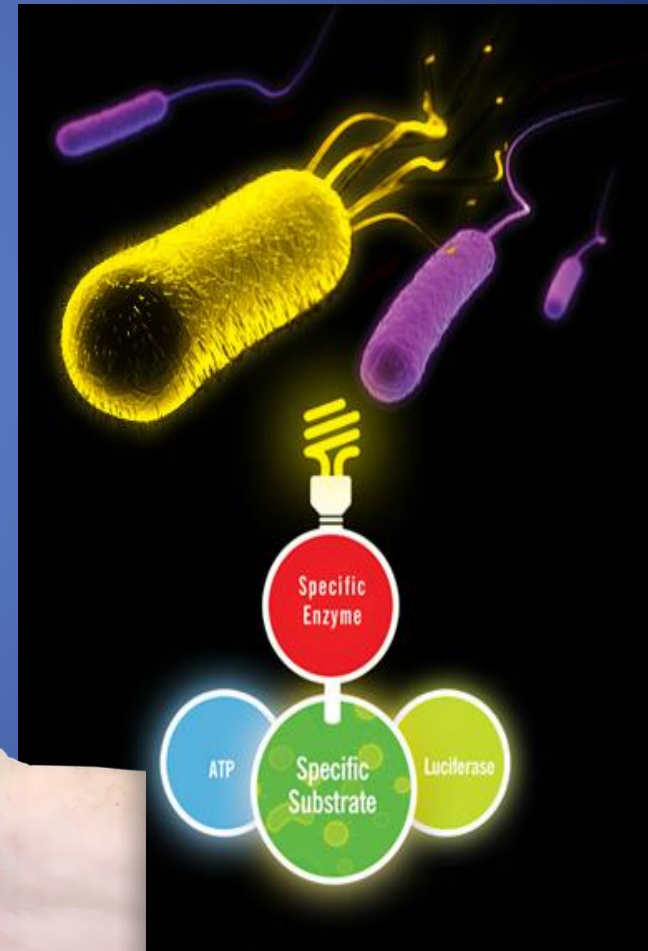


SKC 225-2402



Rapid bioluminogenic test for detection and enumeration of bacteria, giving results in less than 8 hours.

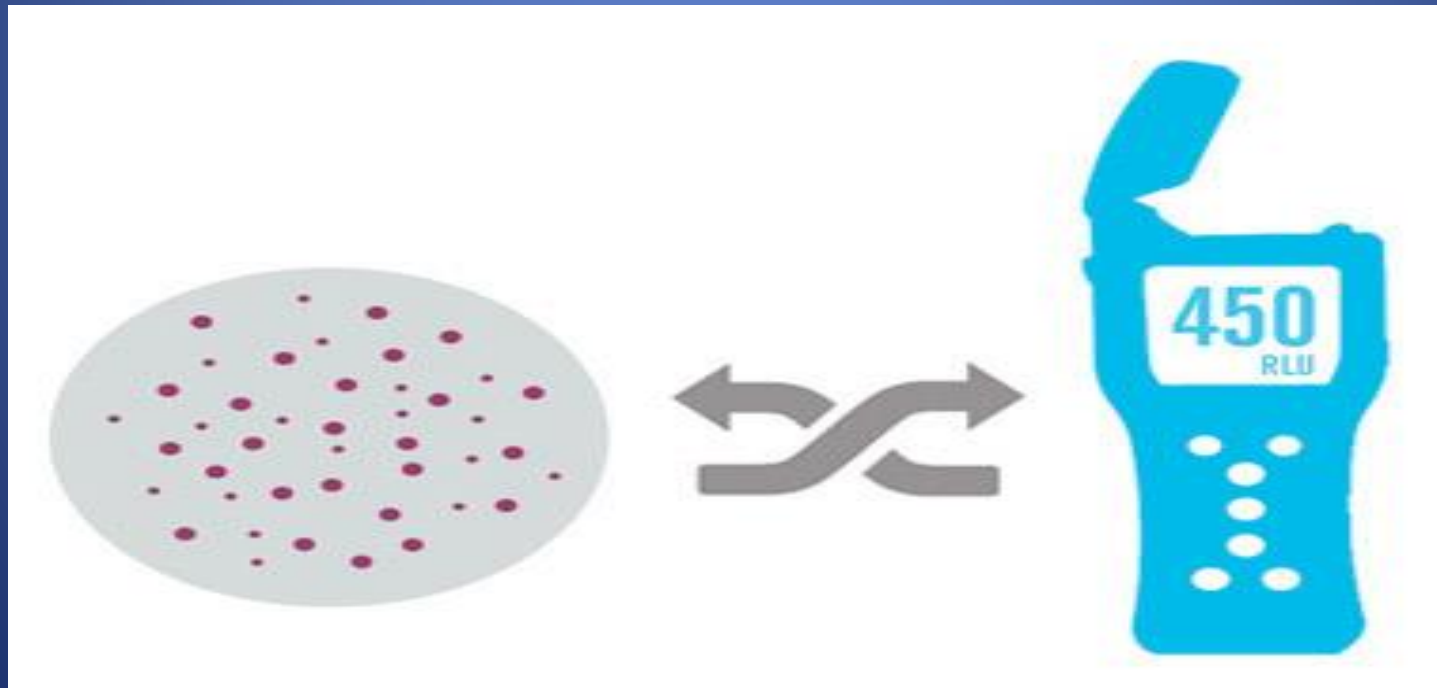
MicroSnap detects the specific microorganism, light is emitted and measured that correlates with contamination levels.



No more counting colonies. - Colony Forming Units

MicroSnap technology derives equivalent CFU values using light detection.
Relative Light Units (RLUs)

EnSURE displays measurements in relative light units (RLU's). The RLU number is correlated to colony forming units (CFU's).





Air Monitoring

1. Air Samplers (active air sampling) –
2. Settling plates (passive air sampling) -
Petri dishes

USP 797 Environmental Monitoring in pharmaceutical compounding

- Nonviable airborne particle sampling – electronic particle counter
- Airborne bacteria and fungi
- Viable surface sampling
- Gloved fingertip sampling – TSA plates

Pharmacy Recommended Action Levels.

ISO Class	$\geq 0.5 \mu\text{m}$ Nonviable Particles/m^3	Viable Airborne (cfu/m^3)	Viable Surface (cfu/contact plate)
3	3,520	> 1	> 3
7	352,000	> 10	> 5
8	3,520,000	> 100	> 100

The United States Pharmacopeial Convention. <797> Pharmaceutical Compounding - Sterile Preparations. Revision Bulletin. 2008, p. 1-61.

Patient and Worker Monitoring

- Workers
 - Contaminated hands/clothing
 - Use of Personnel Protective Equipment
 - TB screening
 - Medical surveillance
 - Hepatitis evaluation
- Patients
 - Patient screening
 - Many contaminations come from the patients themselves (Duckro, 2005)

Equipment Monitoring

- Arthroscopic instruments (Tosh, 2011)
- Ventilation equipment contamination and respiratory tract infections with *Acinetobacter* (Cefai, 1990)(Castle, 1978)



Air Flow Monitoring

- Laminar flow
- Pressure differentials
- Directional flow
- Volumetric analysis
- Distribution and recirculation systems
- Building and renovation commissioning
- Critical care and activities
 - TB isolation, other isolation, pharmacy, oncology, dialysis



Water Monitoring

Water and Sanitation for Health Facility Improvement Tool (WASH FIT)

A practical guide for improving quality of care through water, sanitation and hygiene in health care facilities



Controls

- Prevention through Design (PtD)
- Elimination and Substitution
- Engineering Controls
- Administrative Controls
- Personal Protective Equipment

Prevention Through Design

- Patient flow
- Ventilation systems
- Waste handling
- Morgue design and size

Engineering Controls

- Ventilation
- Cleaning, disinfection, sterilization
- Ultraviolet radiation
- Fumigation
- Safety devices
- Waste handling

Ventilation

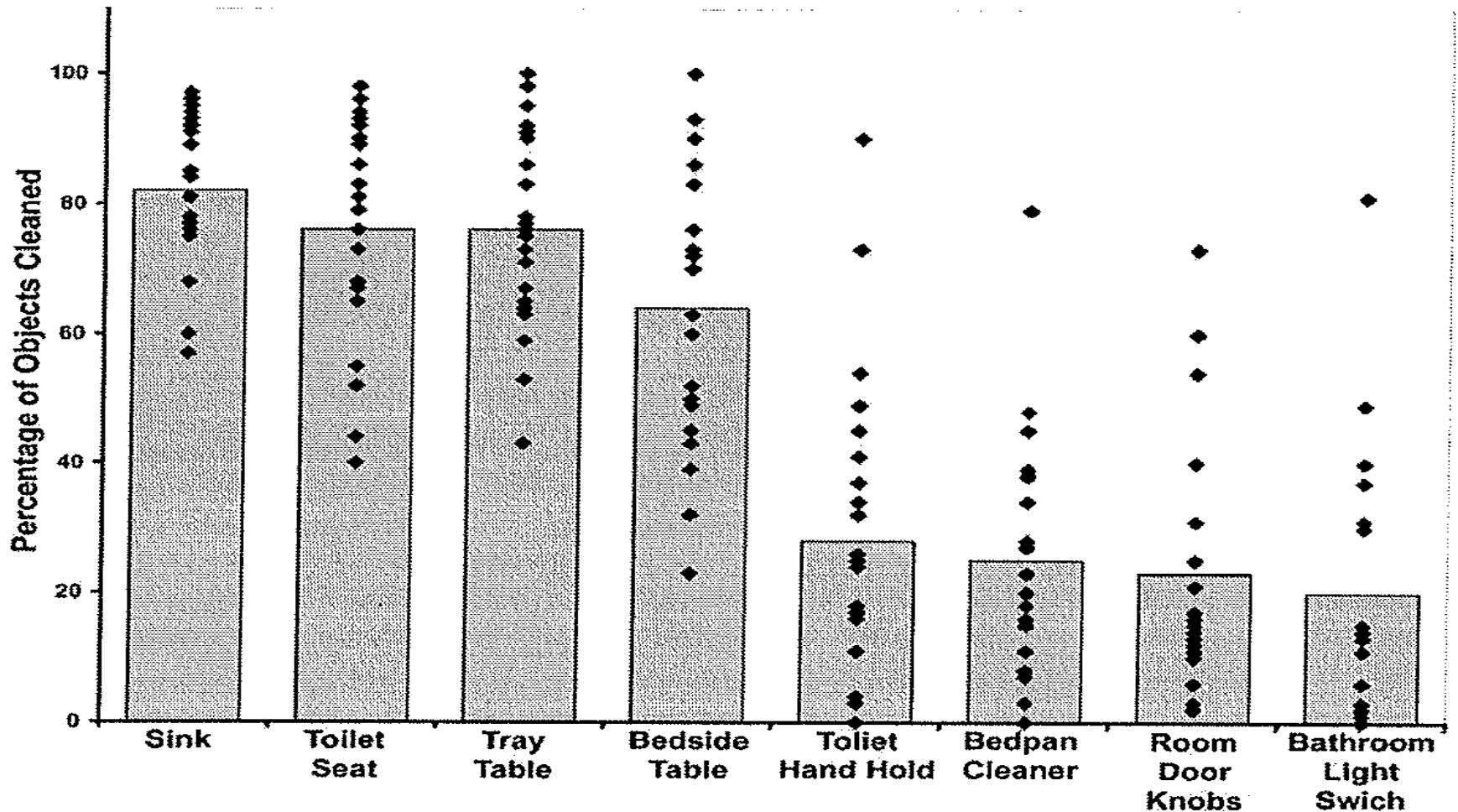
- Personal experiences;
 - Sterile supply pulling in air from the loading dock and waste handling area,
 - Surgical airflow NEVER tested,
 - Critical care pharmacy operations pulling air in from the adjacent hallway,
 - TB isolation rooms under positive pressure blowing contaminated air into the hallway,
 - Immunocompromised patient rooms pulling hallway air into the patient breathing zones.

Ventilation

- Is airflow from Sterile Supply positive in association with adjacent areas? How often is this tested, by whom?
- Are surgical unit ventilation supplies and flows tested on a regular basis, are they laminar?
- Are ventilation isolated areas identified and evaluated?
- Do pharmacy unit ventilation flows adhere to accepted standards of practice? Have you seen the documentation?

Environmental Cleaning and Disinfection

- 23 hospitals showed a broad range of cleaning effectiveness (Carling, 2008)

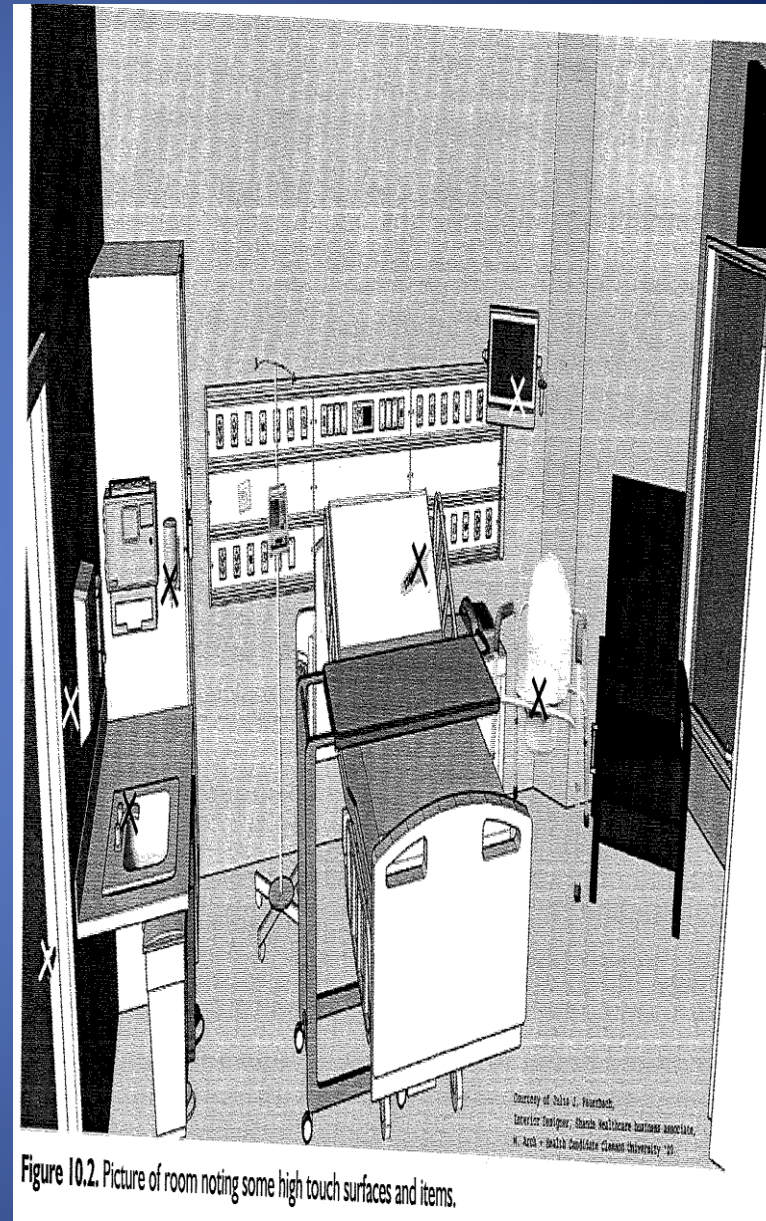


Environmental Cleaning and Disinfection

- Increased probability of MRSA and VRE for patients in rooms previously occupied by MRSA and VRE positive patients (Huang, 2006)
- Demonstrates a need for advanced training of Environmental Services and Nursing staff. (Huang, 2006)

Environmental Cleaning and Disinfection

- Disinfection of specific focused surfaces in patient-care areas
(Kramer, 2006)(Drees, 2008),
- Sodium Hypochlorite for C. diff.,
cleaning only for floors (APIC, 2008)
- Use of an EPA registered
disinfectant in accordance with
manufacturer instructions (Hota, 2004)
- Consistent cleaning behaviors
and training (Hota, 2004)(Eckstein, 2007)
- Daily and terminal
cleaning/disinfection (Schulster, 2003 HIPAC
MMWR)



Ultraviolet Radiation

Ventilation Systems



Water Treatment Plants



Hand-Held Surface Cleaning



Laboratories



Surgical Suites



In-Room Systems



Ultraviolet Radiation

- Hazardous to patients and workers,
- Not clearly associated with reductions in HAIs,
- Expensive and time consuming to use in practice,
- Very effective at disinfecting ceilings and walls, but not particularly effective in disinfecting primary “high-touch” contaminated areas like bathroom faucets and telephone key pads.

UV Health Effects

- Acute Effects
 - Keratoconjunctivitis (snow blindness)
 - Erythema (sun burn)
 - Skin Photosensitization
- Chronic Affects
 - Cataracts
 - Skin Aging
 - Skin Cancer (Group 2A carcinogen)

Ultraviolet Radiation

- Extremely dangerous and difficult to control,
- The benefits of disinfecting/sterilizing the ceilings and walls is questionable,
- The UV light can't get behind materials where remaining agents may remain for weeks or months,
- The effects to tissue other than skin are completely unknown at this time???

Fumigation



Fumigation

- Use of an extremely lethal/toxic chemical gas or vapor released into the room for a duration up to 4 hours,
- Very dangerous to use in a hospital setting where immunocompromised, and respiratory distressed patients could be potentially exposed,
- Requires ongoing diligent monitoring and safety programs to ensure implementation on a regular basis.

TABLE II. Comparison of EPA Approved Disinfection Fumigation Methods/Chemicals

Vendor	Chemical	Concentration	Time			STEL	IDLH
		(ppm)	(hours)	PEL (ppm)	TLV (ppm)	(ppm)	(ppm)
Sabre	Chlorine dioxide	3,000	3	0.1	0.1	0.3 ^A	5.0
CDG	Chlorine dioxide	2,000	6	0.1	0.1	0.3	5.0
CERTEK	Formaldehyde	1,100	11	0.75 ^B		^C	20.0
BIOQUELL	Hydrogen peroxide	1,000	1	1.0	1.0		75.0

The Risks and Benefits of Chemical Fumigation in the Health Care Environment

George Byrns and Thomas P. Fuller

CONCLUSION

Fumigation in health care facilities and other related institutions should be limited to those instances where the benefits clearly exceed the risks of human exposure or environmental damage. Decontamination of an unoccupied building following a bioterrorism incident would meet this criterion. In situations where the building is occupied and the potential for recontamination is high, the benefits of fumigation do not appear to exceed the risks. Before potentially risky procedures such as fumigation are considered, simpler and safer approaches such as enhanced cleaning should be considered.

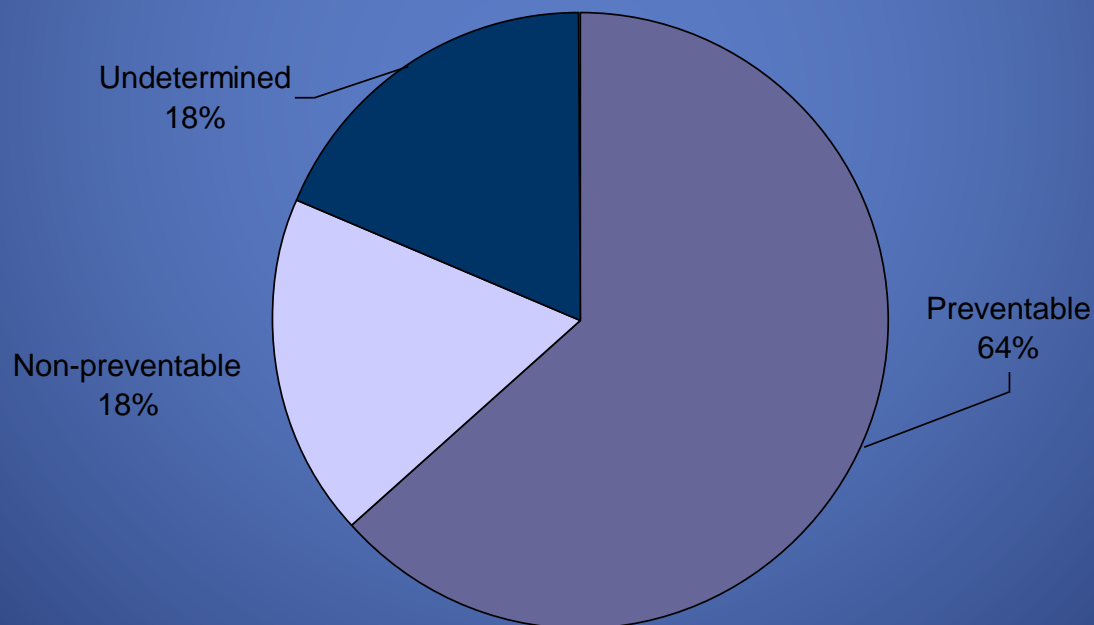
Safety Devices and Sharps Injuries

- CDC estimates ~385,000 sharps injuries annually among hospital-based healthcare personnel*
- Sharps injuries are a hazard
 - Increased risk for bloodborne virus transmission
 - Cost to workers and healthcare system

*Panlilio AL, et al. *Infect Control Hosp Epidemiol*, 2004

Sharps Injuries Are Preventable

Preventability of Needlestick Injuries involving Hollow-bore Needles in 78 NaSH Hospitals, June 1995 to December 2004 (n=11,625)



Safety Devices



**NOW
YOU SEE IT.**



**NOW
YOU DON'T.**

Safety Devices



**NOW
YOU SEE IT.**



**NOW
YOU DON'T.**

Sharps Disposal Containers



Microwave Waste Sterilization



http://www.sterilwave.com/wp-content/uploads/2014/10/Plaqueette_Sterilwave_BD2.pdf

Microwave Waste Management

<http://ecosteryl.com/>



Ecosteryl Serial 250 - 3D model



Administrative Controls

- Vaccines
- Testing
- Training
- Screening of patients and workers
- Policies, programs, procedures and Enforcement
- Prophylactic treatments/Post exposure treatments
- Inspections, audits, reviews
- Records



Training

- New infectious agents
- Handwashing (germglow)
- PPE
 - Donning
 - Doffing



Personnel Protective Equipment

- Respirators
- Eyewear/goggles
- Suits/jackets
- Gloves/sleeves
- Face shields
- Booties
- Ear plugs/muffs



Personnel Protective Equipment

- 66-75% of nurses practice PPE compliance (Knight, 1998, Evanoff, 1999, Sadoh, 2006)
- Only 5% of surgical nurses wore all components of PPE (Ganczak, 2007)
- During hospital trauma resuscitations with visible blood, only 38% of workers wore proper PPE (Madan, 2001)
- ED workers wore gloves 75% of the time when required by isolation precautions (Chiang, 2008)
- 40% of HCWs do not receive OSHA required annual respirator fit-test training (Bryce, 2008)

Reasons for Poor PPE Use

- Inconvenient and inaccessible
(Daugherty, 2009)
- Perceptions that PPE does not work, or that the patients are low risk
(Ferguson, 2004)
- Management and supervisory oversight that clearly state policies, and do not enforce PPE use.
(Daugherty, 2009)(Scott, 2005)(Gurses, 2008)(Lombardi, 2009)



Toronto SARS Outbreak Initial Basic Personal Protection



Lapinsky: 2009 Slide 51

Toronto SARS Outbreak progressive Personal Protection



Toronto SARS Outbreak progressive Personal Protection



Surgical cap

Goggles + face-shield

N95/N100 mask

Double gloves

Double gown

Surgical scrubs

Avoid fabric shoes



Toronto SARS Outbreak Final Personal Protection

3M Airmate PAPR

PPE Considerations

- Effectiveness/simplicity
- Cost
- Availability
- Worker knowledge/awareness/capabilities

Review

- HAIs continue to be a growing concern,
- Healthcare workers and the system are at significant risk
- Sources of infection are numerous and pervasive,
- A variety of control methods are available, some are more effective than others.

Recommendations

- A comprehensive integrated and coordinated approach will be most effective,
- Better worker awareness and training on a variety of levels in different categories,
 - Cleaning, Sterilization, PPE
- Improved analysis and control over important ventilation systems integral to infection control
 - Surgery, pharmacy, dialysis, isolation, sterile supply
- Beware of “Silver Bullets” with unproven effectiveness and significant risks to workers and patients (i.e. Ultraviolet Radiation and Fumigation).

Thank You!!!

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