Engineered **Infection Prevention**

Barry Hunt

Chair, Coalition for **Healthcare Acquired Infection Reduction**
MISSION

CHAIR Canada is committed to saving lives and supporting the creation of a safe healthcare environment for Canadian patients, staff and visitors by achieving an 80% reduction in healthcare acquired infections (HAIs) by 2024.


Barry Hunt  1.519.749.5267  barryhunt@chaircanada.org  Chair
Richard Dixon  1.604.619.1768  richard.dixon@chaircanada.org  Deputy Chair
Marian Marshall  1.519.212.6594  marian.marshall@chaircanada.org  National Facilitator
Engineered Infection Prevention

“2017 Top 10 World Patient Safety Innovation”

Patient Safety Movement
Engineered Infection Prevention

<table>
<thead>
<tr>
<th>Materials, technology &amp; automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>built into hospital</td>
</tr>
<tr>
<td>infrastructure</td>
</tr>
<tr>
<td>to reduce the environmental route</td>
</tr>
<tr>
<td>of disease transmission, including</td>
</tr>
<tr>
<td><strong>air, water &amp; surfaces.</strong></td>
</tr>
</tbody>
</table>
Bacteria Killing Mechanisms

- UV
- Cu+
- DNA
- Organelles
- Membrane
- O₃
- Cu+
Disinfection Revolution

1850: Soap & Water
1900: Bleach
1950: Chemicals
2000: More Chemicals
Today: Intelligent Self-Disinfecting Hospital

Chemicals Humans
Intelligent Self-Disinfecting Hospital

- Smart, targeted, event-based disinfection
- Big Data
- AI
- Automated
- Thermal Imaging
- Machine Vision
- Networked
- WiFi, BT, LORA-Wan, Weightless-P
- Secure Cloud-based database
- User Portals
- Clinically relevant APIs
- GDPR-compliant privacy

UV
Cu+
O₃
HAI Prevention

- Engineered Infection Prevention
- Engineering controls: 99.9999%
- Substitution
- Elimination
Repeatable

Effective

Cost-effective

Spread & Scale

Humans

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass</td>
<td>99.9999%</td>
</tr>
<tr>
<td>Fail</td>
<td>0.00001%</td>
</tr>
</tbody>
</table>
Quantitative Microbial Risk Assessment

QMRA

preventive, risk-based approach from source to exposure for the management of microbial hazards

Water, Food Safety
QMRA

\[ C_{\text{hand}, T} = \sum_{j=1}^{m} \left( H_{\text{surface}, j} \times f_{12,j} \right) \times C_{\text{surface}} \times FSA \]

\[ \alpha_{\text{die-off}} = \left( \sum_{j=1}^{m} \left( H_{\text{surface}, j} \times f_{12,j} \right) \right) \times FSA + \frac{\sum_{n=1}^{N} \left( H_{\text{water}, n} \times A_{\text{water}, n} \right)}{H_{\text{water}}} \]

**Contaminated Door Knob**

1000 Rhinoviruses
50% Transfer
Hand
100 Viruses
10% Transfer
Nose
10 Viruses

**Transmission**
Frequency of contact
Duration of contact
Type of interaction
Type of procedure
Surgical site

**Facility Characteristics**
- Number of units
- Number of employees
- Number of beds
- Number of patients
- Type of patients
- Patient days
- Infection control

**Reservoir/Source**
- Environment
- Instrument/device
- Person

**Hazard**

**Exposure**

**Dose-Response**

**Infection**
- Susceptibility
- Severity rate

**Infection Risk**

<table>
<thead>
<tr>
<th>% Reduction in Viral Concentration</th>
<th>Rotavirus</th>
<th>Rhinovirus</th>
<th>Influenza A virus</th>
</tr>
</thead>
<tbody>
<tr>
<td>94.1%</td>
<td>5.10 x 10^{-3}</td>
<td>1.77 x 10^{-3}</td>
<td>2.02 x 10^{-8}</td>
</tr>
<tr>
<td>99%</td>
<td>9.46 x 10^{-4}</td>
<td>3.09 x 10^{-4}</td>
<td>3.64 x 10^{-9}</td>
</tr>
<tr>
<td>99.9%</td>
<td>9.24 x 10^{-5}</td>
<td>3.19 x 10^{-5}</td>
<td>3.51 x 10^{-10}</td>
</tr>
<tr>
<td>99.99%</td>
<td>9.66 x 10^{-6}</td>
<td>3.09 x 10^{-6}</td>
<td>3.79 x 10^{-11}</td>
</tr>
<tr>
<td>99.999%</td>
<td>9.48 x 10^{-7}</td>
<td>3.05 x 10^{-7}</td>
<td>3.58 x 10^{-12}</td>
</tr>
</tbody>
</table>

**Hand washing opportunity**
Non porous fomite contact
Porous fomite contact
Mouth contact
Eye contact
Nose contact
No contact

**Courtesy:** Dr. Kelly Reynolds, U of Arizona
< 1 / 1,000,000

EIP Target

Risk of transfer, exposure & infection for each contact
10 to 100 CFU / cm² = 40%

Risk of Transfer
This QMRA analysis suggests that a reduction in bacterial numbers on a fomite by 99% (2 logs) most often will reduce the risk of infection from a single contact to less than 1 in 1 million.
< 1 / 1,000,000

EIP Target

Risk of transfer, exposure & infection for each contact
<1 CFU / cm² = 1/1,000,000

UV ~ 0.1 CFU/cm²
Cu⁺ ~ 0.5 CFU/cm²
Bathroom

UV On

.12 CFU/cm²

< 1/1,000,000

UV Off

~10 CFU/cm²

40%

Courtesy: Dr. Bryce
Equipment Room

< 1/1,000,000

40%

Courtesy: St. Mary’s General Hospital
Manual Disinfection – How It Works

25% of Surfaces Briefly Disinfected Daily
AutoAir Disinfection – How It Works

Continuously Reduces Aerosol Transmission, Surface Contamination
Copper Surfaces – How It Works

Continuously Reduces Surface Contamination of High Touch Surfaces
AutoUV – How It Works

Briefly Reduces 97% of Surface & Air Contamination
AutoUV + AutoAir+ Copper Surfaces & Linens

Engineered Infection Prevention
AutoUV + AutoAir + Copper Surfaces

Engineered Infection Prevention
AutoUV + AutoAir+ Copper Surfaces

Engineered Infection Prevention
### Imagine...

<table>
<thead>
<tr>
<th></th>
<th>Today’s Hospital</th>
<th>Tomorrow’s Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touches</td>
<td>160,000,000</td>
<td>160,000,000</td>
</tr>
<tr>
<td>Bacterial Transfers</td>
<td>64,000,000</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Hand Hygiene</td>
<td>63,000,000</td>
<td>20,000,000</td>
</tr>
<tr>
<td>Alcohol-Based Handrub</td>
<td>57,000,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Contact Precautions</td>
<td>1,600,000</td>
<td>16,000</td>
</tr>
<tr>
<td>Chemicals</td>
<td>109,500</td>
<td>1,000</td>
</tr>
</tbody>
</table>

**300 Beds**
Contact Precautions

Typical: C. Diff, MRSA, VRE

Could we discontinue?

50 US Hospitals already have

300 Beds - $2,000,000

$200 / pt / day

Technology is way cheaper

Direct Costs of a Contact Isolation Day: A Prospective Cost Analysis at a Swiss University Hospital

Jan A. Roth, MD,1,2 Claudia Hornung-Winter, PhD,1,2 Isabel Radicke,2,2 Baltasar L. Hug, MD, MBA, MPH,2,3 Monika Biedert,2,2 Christian Abshagen, MD, MBA,2,2 Manuel Battegay, MD,1,2 Andreas F. Widmer, MD, MS,1,2

We prospectively evaluated direct costs of contact precautions using on-site observation. Additional mean costs per patient day were calculated for extra materials used, increased workload, and one-off isolation activities. The cost of contact precautions was $158.90 (55% confidence interval, $124.90–$192.80) per patient day.

Infect Control Hosp Epidemiol 2018;39:101–103
Effectiveness Adjusted

# Disinfections Per Year

- Cloths (Daily): 54,750
- Mobile UV (Terminal Clean): 12,070
- AutoUV: 2,000,000
Relative Impact
Hospital Disinfection

- Cloths (Daily): 2.7%
- Mobile UV (Terminal Clean): 0.60%
- AutoUV: 100%
<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Copper</td>
</tr>
<tr>
<td>2014</td>
<td>AutoUV Bathrooms</td>
</tr>
<tr>
<td>2016</td>
<td>Ozonated Water Sinks</td>
</tr>
</tbody>
</table>
Self-disinfecting
Patient Room
Eye-in-the-sky
Wireless
IoT Connected
Data analytics
Patient activation
Networked
Intelligent EIP – Large Rooms
Manual Disinfection vs AutoUV

- **Auto UV**
  - 4X Coverage
  - 20X Frequency
  - 80X Stopping Power

STOP
AutoUV

Occupancy Detection
Door contacts
Smart Logic

Bathrooms
Clean & Soiled Utility
Equipment Storage
Processing Rooms
AutoUV Studies

Cooper, Bryce 2016  Case Study  95% to 97% bio-reduction

ARTICLE IN PRESS

American Journal of Infection Control (2016)

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Brief Report

Efficacy of an automated ultraviolet C device in a shared hospital bathroom

Jesse Cooper BSc a,⁎, Elizabeth Bryce MD, FRCPC b, George Astrakianakis MEng, PhD a, Aleksandra Stefanovic MD, FRCPC b, Karen Bartlett MSc, PhD a

a School of Population and Public Health, University of British Columbia, Vancouver, BC, Canada
b Division of Medical Microbiology and Infection Control, Vancouver Coastal Health, Vancouver, BC, Canada
AutoUV Studies

Hunt 2016 Case Study 32% door close compliance, 65% bathrooms protected

Infection Control.tips

Reduction of Hospital Environmental Contamination Using Automatic UV Room Disfection

Barry Hunt, William A. Anderson

Edited by: Andrew Duong
Reviewed by: Michael Rochon, Uyen Nguyen

Conflicts of Interest
Barry Hunt – President & CEO of Class 1 Inc.
William Anderson – none.

Abstract
The use of mobile ultraviolet (UV) germicidal irradiation has been documented to reduce contamination levels and HAIs in hospitals. However, there is a general lack of information on the efficacy of wall-mounted, automated UV systems that are designed to irradiate rooms whenever they are left unoccupied. In this study, the Ascentix 1 UVC device (which includes two motion detectors, a magnetic door...
AutoUV Studies

Anderson 2018 Case Study significant bioreduction

Safer Chemicals Best Practice Case Study #2

Effects of Automated UV Disinfection Device on Microbial Loads on Surfaces and in the Air in a Chatham-Kent Health Alliance Washroom

Prof. W. A. (Bill) Anderson P.Eng., Department of Chemical Engineering, University of Waterloo

Study Purpose

To compare differences in environmental microbial loads in a washroom located on CKHA’s Chatham Campus, before and after activation of an automated UV disinfection unit. Standard cleaning practices and procedures were maintained throughout the course of this study.

Study Design

One washroom was sampled for five days with the UV system operating and another five day period with the UV system inactivated. The UV system (ASEPTIX) automatically turns on to disinfect the room for five minutes after each time the room is entered and used, as detected by a door switch and built-in occupancy sensor. For safety purposes, these sensors also prevent the UV system from activating when the room is occupied. Figure 1 shows the UV device location within the washroom.

The Chatham-Kent Health Alliance’s is committed to core service excellence, top-flight operational performance and to becoming a facility of choice in Southwestern Ontario. With sites in Chatham and Wallaceburg, CKHA is comprised of approximately 1,300 compassionate staff, 178 physicians and 300 volunteers who serve the medical needs of over 100,000 patients in the Municipality of Chatham-Kent. Chatham Campus pictured above.
**Background**

- Ultraviolet-C (UV-C) radiation is effective in killing a wide range of viral and bacterial pathogens, including *Clostridium difficile* spores.
- However, operation of mobile UV-C decontamination devices can be cumbersome and time consuming to deploy.
- We tested the efficacy of an automated, wall-mounted UV-C device designed for decontamination of patient restrooms after each use.

**Objective**

- To evaluate the efficacy of a patient-activated, low-pressure mercury UV-C room decontamination device against common hospital pathogens.

**Methods**

- The ASEPT1X system is a UV-C device mounted above the door frame in restrooms that utilizes a door safety monitor as well as motion and infrared sensors to assess if the bathroom is currently or has previously been occupied (Figure 1).
- A 5-minute UV-C decontamination cycle is triggered after each use of the restroom; the cycle is aborted if the door is opened or motion is detected (Figure 1).
- We tested the efficacy of the device against methicillin-resistant *Staphylococcus aureus* (MRSA), *C. difficile* spores, and bacteriophages MS2 and Phi X174.
- Pathogens were inoculated onto steel discs and exposed to 1, 3, or 6 UV-C cycles (Figure 2).

**Results**

- A single 5-minute cycle reduced recovery of MRSA by greater than 3.4 log_{10} CFU.
- Viruses were reduced by ≥1 log_{10} PFU in single 5-minute cycle.
- Three cycles of exposure (15 minutes total) were required to achieve a ≥2 log reduction in *C. difficile* spores (Figure 2).
- The safety features of the device were effective in preventing UV-C exposure upon room entry (Figure 1).

**Conclusions**

- Our results suggest that an automated, wall-mounted UV-C device could provide a useful adjunct to manual cleaning of patient bathrooms with minimal added workload for environmental services personnel.

**Acknowledgement**

- Class 1 Inc. provided the ASEPT1X system for testing but did not fund or have any role in planning or design of the study.
Today’s Hospital...

Spot cleaning & **disinfecting** with ☠️ **chemicals** & cloths

- Declutter ✓
- Clean ✓
- **Disinfect**
- Set-up ✓

<table>
<thead>
<tr>
<th>Task</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>15 min</td>
</tr>
<tr>
<td>Terminal Clean</td>
<td>30 min</td>
</tr>
<tr>
<td>Isolation</td>
<td>45 min</td>
</tr>
</tbody>
</table>
250 kg of toxics and other waste per year to water from healthcare facilities
Tomorrow’s Hospital

Spot cleaning with **ozonated water** & cloths

- **Self-disinfecting surfaces**
- **Declutter**
- **Clean**
- **Set-up**

**Daily** 15 min
**Terminal Clean** 30 min
**Isolation** 45 min

**AutoUV**
Surfaces & Disinfection

Evaluating emerging materials and technologies for infection prevention and control

Intro to EIP 2015
Proposed New CSA Standard

Z80XX.XX-20 Cleaning and disinfection of healthcare facilities for infection prevention and control

Surfaces & Disinfection
- Surfaces
- Technologies
- Processes
- Risk management
Chair - Richard Dixon

2018 CSA Award of Merit

The sky over Edmonton, AB, on March 14th, 2006
Ideal Patient Rooms

1. Single
2. High-frequency Self-disinfecting bathroom AutoUV + Copper
3. High-frequency Self-disinfecting hand hygiene sinks AutoROS Water
4. High-frequency Self-disinfecting Patient Room AutoUV
5. Continuous Fast-acting self-sanitizing high-touch surfaces Copper
6. Continuous room air disinfection UV Air
7. *Continuous low level disinfection of general surfaces TiO2, 405nm

*Iff not using high-frequency automated disinfection
1. 100% Fresh Air
2. 50% Relative Humidity (+/- 5%)
3. Individual Temperature Control
4. HEPA Filtration
5. UVC Coil Cleaners
6. UVC Air Disinfection – Recirc, Critical Areas
7. VOC removal – NICU, Nursery, IVF
Ideal Water

1. 100% UV Disinfection incoming water supply
2. Copper-Silver Ionization
3. Auto-flush / circulation devices
4. Tepid water loop for sinks (38° to 40° C)
5. Clear water re-use line for toilets
6. Point-of-use ozonated / ROS water sinks & dispensers
7. Copper pipes
“Healthcare needs positive innovation.”
2016 National Healthcare Leaders Conference

“Innovation strong”

The Honourable Dr. Jane Philpotts,
Federal Minister of Health

“Implement innovations now”
Engineered Infection Prevention

Health Ministry Engagement
Humber River Hospital – Reactivation Centre

Redevelopment project of older site

5 Hospitals sharing space for overflow patients

Primarily 2-bed rooms, shared bathrooms

• 131 self-disinfecting bathrooms

Mandated EIP - Fall 2017
Ontario MOHLTC Position on EIP

MOHLTC now funds and mandates EIP for new projects:

<table>
<thead>
<tr>
<th>In CSA Standards</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not in CSA, literature supported</td>
<td>Recommended</td>
</tr>
<tr>
<td><strong>Shared bathrooms</strong></td>
<td><strong>Mandatory</strong></td>
</tr>
<tr>
<td><strong>Shared Patient Rooms</strong></td>
<td><strong>Mandatory</strong></td>
</tr>
<tr>
<td><strong>High Risk &amp;/or high-profile</strong></td>
<td><strong>Mandatory</strong></td>
</tr>
</tbody>
</table>

Fall 2017
EIP Projects – Too Late?

- Mt. Sinai Redevelopment
- Brockville Redevelopment
- Michael Garron Redevelopment Likely!!!
- Calgary Cancer Centre New Hospital
- WestPark New Hospital Likely!!!

~ 1.6B

~ 1,600 beds
## EIP Projects – Design Phase

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Mary’s General</td>
<td>Cardiac</td>
<td>2018</td>
</tr>
<tr>
<td>Foothills Hospital</td>
<td>Regional NICU</td>
<td>2019</td>
</tr>
<tr>
<td>Vancouver General</td>
<td>New ORs</td>
<td>2019</td>
</tr>
<tr>
<td>BC Cancer Centre</td>
<td>Outpatient</td>
<td>2019</td>
</tr>
<tr>
<td>Sick Kids</td>
<td>Redevelopment</td>
<td>2020</td>
</tr>
</tbody>
</table>

~ 1,000 beds  

~ 5B
Existing Hospitals

2,000 Ontarions are likely in hospital this week due to HAI

100 will never go home to see their loved ones again
Last 3 Years

- Honourable Dr. Eric Hoskins, Minister of Health (former)
- MPP Kathryn McGarry, Minister of Transportation
- MPP Daiene Vernille, Minister of Tourism
- MPP Catherine Fife
- MPP Michael Harris
- MPP Arthur Potts
- MPP Charles Sousa, Minister of Finance
- Standing Committee on Finance
Retrofit Existing Hospitals...

Last 3 years...

200,000 Ontarions have been infected

10,000 Ontarions have died
## Existing Ontario Hospitals

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare Acquired Infection Rate</td>
<td>11.1%</td>
</tr>
<tr>
<td>Expected HAI Reduction</td>
<td>50%</td>
</tr>
<tr>
<td>Chemical Reduction (Patient Rooms)</td>
<td>50%</td>
</tr>
<tr>
<td>Contact Precautions PPE Reduction</td>
<td>50%</td>
</tr>
<tr>
<td>ROI (Months)</td>
<td>11.2</td>
</tr>
<tr>
<td>ROI (Years)</td>
<td>0.9</td>
</tr>
<tr>
<td># of Beds</td>
<td>25,000</td>
</tr>
<tr>
<td>Annual Savings ( Millions)</td>
<td>$1,115.2</td>
</tr>
<tr>
<td>30y Savings ( Millions)</td>
<td>$58,292</td>
</tr>
<tr>
<td>30y Infections Prevented</td>
<td>1,801,682</td>
</tr>
<tr>
<td>30y Lives Saved</td>
<td>90,084</td>
</tr>
</tbody>
</table>

Savings!  
Lives!  
ROI!
17 Years

Innovation to Implementation

[Canadian flag]
17 Years Costs...

3.4 million infections

170,000 deaths

34 billion dollars

(assuming things don’t get worse)
Semmelweis Reflex

The tendency to reject new evidence or new knowledge because it contradicts established norms, beliefs or paradigms.

Legacy Thinking
80:20 Rule of Change Management

- Champion: 80%
- Skeptic: 10%
- ???: 80%
Engineered Infection Prevention

“2017 Top 10 World Patient Safety Innovation”
Today

Tomorrow

1/10

1/1,000,000

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