ENGINEERING HEALTHCARE ACQUIRED INFECTION REDUCTION

By Barry Hunt

Healthcare Acquired Infections (HAIs) are the fourth leading cause of death in Canada after heart attacks, cancer, and stroke. Thirty years ago, the chance of catching an HAI as an in-patient in a Canadian hospital was about 2%. Today, it's over 10%.

Unless we take action, the odds of becoming infected in thirty years will be one in four. Moreover, the cost of treatment for each infected person has risen from a few hundred dollars to over $20,000 with no end in sight. By 2050, the total cost of treatment for HAIs in Canada could approach $40 billion dollars.

For years, we have focused primarily on asking staff to wash their hands and wear gowns and gloves for known infectious cases. Obviously, we need to do more. Albert Einstein once said: "The definition of insanity is doing the same thing over and over and expecting different results". In the 90s, Dr. Robert Weinstein also said the following about infection control: "Given the choice of improving technology or improving human behaviour, technology is the better choice".

I would agree, but argue that we need to combine both technology and behaviour change. Also, thought. Therefore, we need engineering.

The Coalition for Healthcare Acquired Infection Reduction

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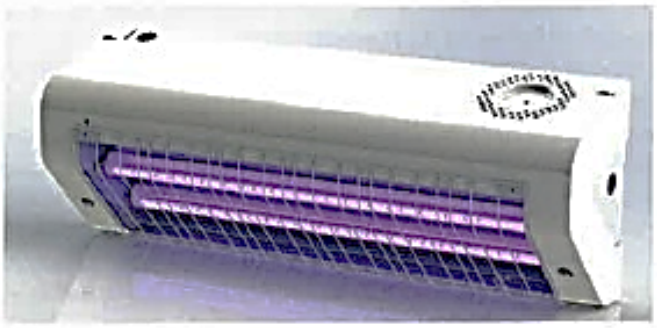

(CHAIR) has identified several practical and cost-effective strategies to achieve the goal of reducing 80% of HAIs in Canada by 2024. The top three strategies involve both technology and engineering, and each strategy has recently been shown to reduce HAIs by over 50%.

Combining these three engineering strategies with cultural, clinical and practice changes throughout the hospital is key to achieving the goal of an 80% reduction.

1. INTERMITTENT SURFACE DISINFECTION USING UVC

Current housekeeping practice generally budgets 15 minutes for daily room cleaning, 30 minutes for terminal cleaning between patients, and 45 minutes for terminal cleaning for isolation cases. This results in less than half of surfaces being cleaned, and the surfaces which are cleaned are disinfected to a level sufficient to prevent regrowth, usually within hours with the materials in use today.

The risk of infection can be double if the prior occupant of a patient room had an infection. We need to achieve a Log6 level of disinfection of all surfaces within the patient room to protect incoming patients. UVC can do this easily. In fact, two independent studies published in 2013 showed >50% reduction in HAIs when a Log6 level of UVC was used to supplement room cleaning between patients.

UVC is a short wavelength light that penetrates the cell wall of microorganisms and alters the DNA structure such that the microorganism becomes non-viable and unable to reproduce. The UVC photons cause neighbouring thymine molecules to bond, thereby preventing further DNA or RNA replication. Unlike antibiotics, this is a physical process for which there is no defense; there is no possible mechanism for organisms to develop resistance to UVC.

Ten years ago, there was one manufacturer promoting the concept of UVC mobile room disinfection. Three years ago there were four. Today, there are over 30. One example of today's UVC technologies is a powerful mobile twin unit that can be placed in the patient room with one light tower on each side of the bed to eliminate shadows. The system is operated with no patient in the room and the corridor door closed. The towers are activated remotely via built-in WiFi and infrared sensors turn off the UVC lights if there is movement in the room. Disinfection time is chosen by the operator considering the distance from the light to the bed, wall, etc. Single patient rooms can be completely disinfected in as little as five minutes.

A new, fully automated fixed UVC device coming on the market in 2015 is targeted toward bathrooms where two out of three superbugs, C Diff and VRE, are known to proliferate. Both are intestinal bacteria associated with explosive diarrhea. Flushing releases infectious toilet aerosols that float for up to 90 minutes, settling on nearby surfaces. Smart sensors enable the unit to automatically disinfect the bathroom to a Log6 level with each and every use in just five minutes. The same device can also be installed in equipment and utility rooms to automatically disinfect equipment and supplies used for patient care.

Bacteria	Distance	5'	6'	7'	8'	9'	10'
	mW/cm2	1314	999	778	620	504	417
Klebs Pneumonia	Seconds	18	24	30	42	48	60
VRE	Seconds	30	36	42	54	66	78
MRSA	Minutes	1.2	1.6	2.1	2.6	3.2	3.8
C diff	Minutes	4.6	6.0	7.7	9.7	11.9	14.4

Low humidity in indoor air is a major contributor to virus transmission.

2. PERSISTENT SELF-SANITIZING SURFACES

In a groundbreaking clinical trial at three major US hospitals, the use of copper on six high touch surfaces (bed rail, IV pole, over-bed table, chair arms, computer keyboard, and monitor) resulted in an HAI reduction of MRSA and VRE of 58% in the ICUs of these hospitals.

The clinical trial was published in the Infection Control and Epidemiology Journal, May 2013. Subsequently, copper and copper alloys have been registered with the US EPA and Health Canada as an antimicrobial product providing Log3 disinfection in less than two hours.

Innovators in this category have developed a copper alloy coating process for hospital furniture surfaces and medical devices. The coating is permanent, won't tarnish, can be applied to most surfaces and is available in a variety of colours and finishes. These can provide up to Log6 disinfection in as little as 30 minutes.

The success of the US copper trial in preventing infections was due in large part to the fast action of copper ions on the membranes and DNA of bacteria and viruses. 97% of the time, when randomly tested, the surfaces in the ICU trial did not have enough remaining viable organisms to effect transmission. There are many other antimicrobial agents on the market in addition to copper such as titanium dioxide, silver, etc. Generally, however, they are slower to act and often do not show a comparable level of disinfection. Slower-acting, persistent, self-sanitizing surfaces however may be appropriate as an adjunct to copper for floors, walls, and ceilings and other low-touch surfaces.

3. ENGINEERING HVAC

Generally speaking, infection comes primarily from the air recirculated within the hospital, not from outside air. However, if HVAC coils, evaporation pans, and filters are not maintained, they can actually add directly to the bioburden of incoming air as well.

Within the hospital, infected patients, visitors and staff shed organisms in patient rooms and bathrooms. Viruses in particular can be airborne in nature (cold, flu, measles, TB) or can become airborne in the form of droplet nuclei when released directly from a patient (sneezing, coughing, talking, suctioning) or from toilet and sink aerosols. Viruses can also be liberated from surfaces where they have previously settled (turbulent air flow, movement of bed linens, curtains and gowns, foot traffic, etc.). Return air provides a path to spread viruses throughout the hospital as viruses pass through most filters. Studies have also shown that the same organisms found in HVAC ducts settle on the surfaces in patient rooms and are the same organisms found in the tracheas of patients. Return air vents should be filtered at the point of entry to reduce the bioload of pathogens from infected patients, and return air should be treated with UVC to eliminate the viruses which pass through the filters.

Low humidity in indoor air is a major contributor to virus transmission. The total level of virus shedding from patients increases with low humidity. The percent of small particles, known as "droplet nuclei", expelled with each cough or sneeze also increases with low humidity. Droplet nuclei travel a lot further and persist in the air a lot longer than larger particles. The combined effect is an exponential increase in virus "spreadability" when the humidity drops.

To make matters worse, patients become dehydrated easily in low humidity environments. Their membranes are more easily breached and their immune system responses are compromised resulting in an increase in "susceptibility". The combined effect of increased spreadability and increased susceptibility is the reason we have a winter "flu season" and "cold season".

Both spreadability and susceptibility are lowest at ~52% relative humidity (RH). Some facilities already have a policy in place to require 50% RH for burn units, bone marrow transplant units, and ORs, usually at the insistence of clinicians based on their experience with patient outcomes. We should be engineering and operating our HVAC systems to provide 50% RH year round to protect all of our patients.

Reducing the organisms in the HVAC supply reduces infections, particularly in areas with ventilated patients. As reported in the Journal of Perinatology in 2011, the HVAC to the NICU at Buffalo Women's & Children's Hospital was supplemented with UVC resulting in a 62% reduction in treatment costs for Ventilator-Associated infections (VAIs). This engineered solution now saves the hospital $850,000 per year.

Another US study on disinfecting HVAC supply air said: "In conclusion, we confirmed the results of two previous studies that demonstrated that an automated UVC device significantly reduced environmental contamination on high touch surfaces in patient rooms."

In 2009, ASHRAE published its "Top 10" priority list for research into "Airborne Infectious Disease Engineering Control Strategies". The top 3 items were UVC surface disinfection, UVC disinfection of HVAC air, and UVC disinfection of upper room air in high-traffic public access areas like cafeterias and waiting rooms. The evidence to support both the first and second are already in. Now, it's time to act.

In the words of Google, engineering is "the branch of science and technology concerned with the design, building, and use of engines, machines, and structures; 2) the work done by, or the occupation of, engineers; 3) the action of working artfully to bring something about". In the hospital world, it's time for us to utilize science and technology to work artfully to reduce HAIs. ■

Barry Hunt is Chairman of the Coalition for Healthcare Acquired Infection Reduction (CHAIR). For more information visit www.chaircanada.org