environmental hygiene

By Richard Dixon

Engineered Infection Prevention: A New World of Better Disinfection of Air, Water and Surfaces

Most people in the Middle Ages believed the world was flat. Brave adventurers such as the Vikings sailed across the ocean to the Atlantic seaboard, and the Chinese journeyed across the Pacific. They began the process of challenging this supposition. It then took several hundred years of voyages of discovery to map out the perimeter of North and South America in addition to inland expeditions such as the mapping experiences of Lewis and Clark in the U.S. and the Hudson Bay Company in Canada to define the nature of this vast land mass.

We do now believe the earth is round, humans have set foot on the moon, probes have landed on Mars, and a trip on a Boeing 787 Dreamliner from Seattle to Paris takes only 11 hours while we sit in comfort sipping a glass of wine. The moral of this story is that new ideas take time to become accepted, practiced, become the new normal and pave the way for the next new idea.

Many healthcare-acquired infections (HAIs) are caused by building-related environmental impacts of air, water, and surfaces, such as high-touch surfaces containing bacteria that are potentially harmful to patients and their subsequent transmission by people from surface to surface. Aerosols can also act as vehicles of microbial transmission. While we once thought medical procedures generated large amounts of aerosols, we now know that common actions like talking, shouting, singing, and coughing, generate far more aerosols than any medical procedures. Even the simple act of flushing the toilet can liberate dangerous pathogens with every use. Recent articles have nicely illustrated that aerosols from toilet plume can be potential vehicles for Clostridioides difficile and norovirus with deposition of infectious particles on bathroom or patient room touch surfaces. While handwashing and daily environmental cleaning have been the mainstays of environmental infection control for the past 170 years, today's healthcare environments need new innovative processes in the battle with newer, more aggressive bacteria, viruses, and molds, such as the emerging threat of Candida auris.

The new 'round' world is about the use of engineered infection prevention (EIP) technologies, materials, automation, and strategies that are adjuncts or even replacements for traditional disinfection of air, water, and surfaces. One of most important risk assessment tools today is the quantitative microbial risk assessment (QMRA)[1]:

- ✓ What level of bacteria/virus reduction is needed to result in a significant risk reduction?
- ✓ What routes of exposure cause the greatest risk of infection?
- ✓ What activities cause the greatest amount of exposure to pathogens?
- ✓ How do pathogens spread via hands and surfaces and aerosolization in different environments? E.g., hospitals, outpatient clinics, urgent care, long-term care, etc.
- ✓ Where does the greatest exposure occur?
- ✓ How effective are hygiene products in reducing infection risks?
- ✓ What is the impact of the number of persons in a facility that practice good hygiene on the other persons in the facility (herd hygiene)?
- ✓ What is the impact of a product or process in practice on disease transmission in each environment?
- ✓ What is the cost/benefit assessment of prevention interventions?

The tendency to reject new evidence or new paradigms such as EIP because it contradicts established norms, beliefs or paradigms is ironically known as the Semmelweis Reflex.[2] Ignaz Semmelweis, of course, went to his grave unable to convince his fellow doctors of the need for hand hygiene to prevent HAIs.

Here are some practical, safe, cost-effective and sustainable examples of EIPs in our new 'round' world.

Germicidal ultraviolet (UV-C) light is a common type of UV well known for one hundred years for its ability to disinfect bacteria, viruses, and mold. Covering the span of invisible light from 200 to 280 nm, the most common and cost-effective wavelength is 254 nm. UV-C photons fuse neighboring thymine and cytosine molecules on DNA strands, thus preventing replication.

UV-C disinfection is commonly used for:

- 1. Water:
  - a. Water treatment
  - b. Wastewater treatment.
  - c. Potable drinking water systems
  - d. Ice machines
- 2. Air:
  - e. "Coil Cleaners" - Industrial and hospital HVAC air handling units to prevent mold, bacteria and biofilm formation in cooling coils, filters, and evaporation pans; very inexpensive and energy-efficient.
  - f. "In-Duct" - Hospital and office tower in-duct air disinfection systems designed to reduce pathogens, especially in recirculated air, which cause HAIs and Sick Building Syndrome, typically up to 99 percent.
  - g. Air Purifiers – Either stand-alone devices or located within devices downstream of HEPA or other filters; often ceiling-mount or portable; typically, 99 percent or higher reduction.
  - h. Upper Air Disinfection - UV-C fixtures installed near the ceiling to create a field of UV-C across the upper part of a room (above 7'6"). The efficiency of the system can be enhanced with ceiling fans that actively draw air into the UV-C field and circulate the air throughout the room.
- 3. Surfaces:
  - i. Mobile – Typically one, two or three UV-C towers on wheels that are manually placed in unoccupied rooms to disinfect spaces between occupancies; especially used in hospitals for "terminal cleans"

between patients,

j. Built-In – Also known as "AutoUV," devices that use redundant occupancy sensors, door contacts and smart algorithms to automatically disinfect spaces when unoccupied 10, 20, 30 times or more per day; typically used in hospital bathrooms, equipment rooms and utility rooms.
k. Robot systems - That autonomously or semi-autonomously disinfect important surfaces in hospitals, pharmaceutical plants, and laboratories.
l. Tunnel Systems – High-speed conveyor-based disinfection systems used in food processing facilities, medical device manufacturers, biohazardous waste recyclers, distribution centres, luggage handling, and secure government mail processing centers.
m. Personal items - Portable UV-C 'box' disinfectors have become popular for disinfecting small personal devices including smartphones, keys, masks, etc., especially since the onset of the COVID-19 pandemic.

UV-C is invisible and can cause sunburn or welder's eye in just a few seconds so it is especially important that systems are designed to protect users against accidental exposure. Only purchase and use UV-C devices from reputable sources that haver registrations and certifications for UV-C from the U.S. EPA[3] and Health Canada. [4]

Relative humidity (RH) in patient care is particularly important. RH in the range of 40 percent to 60 percent[5] is optimal for the health of patients and is the sweet spot where growth and survivability of microorganisms is lowest. Infection rates double when RH drops from 40 percent to 30 percent, patients can also suffer from dehydration and impaired mucous membranes. More than 60 percent RH leads to mold and bacterial growth and can be uncomfortable for patients.

Ideally, for optimal comfort and infection control, RH should be maintained at 50 percent, plus or minus 5 percent. This may be harder to control in an older facility than a newer one with more sophisticated building automation system controls and a better building envelope.[6]

Ozonated water (**OW**) refers to the strong oxidative species often generated by splitting water molecules in the presence of energy and a catalyst in the new 'round' earth. OW is exceptionally good at disinfection and penetrating and preventing biofilms. sanitizer that can be used in the presence of people. In fact, OW is generated and used in our own cells. OW could be used as part of daily cleaning and disinfection process by Environmental Services staff. There are also hand hygiene sinks that generate up to 5 ppm ROS to safely disinfect hands, bowl and drain with each use, preventing microbial growth and the release of pathogenic bioaerosols.[7]

Antimicrobial copper is registered as a biocide in the U.S. by the Environmental Protection Agency (EPA) in 2009 (including recently as effective in reducing coronavirus[8]) and in Canada with Health Canada's PMRA[9] in 2014. Both organizations recognize that when cleaned regularly, antimicrobial copper alloys surfaces kill greater than 99.9 percent of specific bacteria within two hours and continue to kill more than 99 percent of these bacteria even after repeated contamination. Since that time, numerous companies around the (round) earth have contributed to the research and manufacturing of different alloys for various high-touch surfaces:

● Touch surfaces: One of the most common applications of antimicrobial copper is on touch surfaces in healthcare facilities, public spaces, and transportation. This includes items like doorknobs, handrails, bedrails, faucets, and elevator buttons. When these surfaces are made of copper or copper alloys, they can help reduce the transmission of pathogens through touch.

●Overbed tables: These are the most touched surfaces in healthcare, used throughout each day for patient's personal items, food serving, and clinical services like wound treatment, IVs, catheters, and phlebotomy. Overbed tables are virtually never cleaned or disinfected during a patient's stay because environmental services staff are reluctant to remove medical devices or a patient's personal belongings. In a perfect world, all overbed tables would be made of antimicrobial copper.

● Countertops and work surfaces: In settings where hygiene is critical, such as laboratories and food preparation areas, copper countertops and work surfaces are used to inhibit the growth of bacteria and other microorganisms.

● Medical equipment: Copper and copper alloys can be incorporated into various medical devices and equipment, including hospital bedrails, IV poles, and dental instruments, to reduce the risk of HAIs.

● Personal protective equipment (PPE): Copper-infused fabrics and materials are sometimes used in the production of PPE, such as face masks and gloves, to provide an additional layer of protection against pathogens.

● Handrails and guardrails: In public transportation systems like buses, subways, and trains, as well as in crowded public spaces, copper or copper alloy handrails and guardrails can help reduce the spread of germs from hand contact.

It is important to note that while antimicrobial copper can help reduce the presence of harmful microorganisms on surfaces, it is not a substitute for regular cleaning practices. Proper cleaning and hygiene protocols should still be followed in conjunction with the use of antimicrobial copper to ensure the highest level of safety and cleanliness. The effectiveness of antimicrobial copper may vary depending on factors such as the specific copper alloy used, surface morphology, and maintenance. However, it remains a valuable tool in the fight against the spread of infectious agents in various settings.

Silver: This metal has been used for centuries for its antimicrobial properties, and it continues to be used in various medical and industrial applications. Some common uses of silver in this context include:

● Silver dressings: Silver-impregnated dressings are used in wound care to help prevent infection and promote healing. They release silver ions slowly, which can kill or inhibit the growth of bacteria in the wound.

● Silver coatings: Silver coatings or nanoparticles are used in medical devices, such as catheters and implants, to reduce the risk of bacterial colonization and infection.

● Water purification: Silver is sometimes used in water purification systems to disinfect water by killing harmful microorganisms.

● Antimicrobial textiles: Silver nanoparticles can be incorporated into textiles, such as clothing and bed linens, to provide antimicrobial properties and reduce odors.

It is important to note that while silver can be effective against a wide range of microorganisms, including antibiotic-resistant bacteria, its use is not regulated and controlled due to potential toxicity or overexposure of silver ions. Additionally, ongoing research is being conducted to better understand the mechanisms of silver's antimicrobial action and to develop safe and effective silver-based products.

HVAC System Design: Be aware that most older hospitals in the U.S. and Canada use recycled air in their HVAC systems with only recent builds that use 100 percent fresh air. This use of recycled air was for purely 'energy' savings while the newer designs focus on 'infection prevention' savings. Ironically though, the most energy efficient hospital HVAC system in Canada, Humber River Hospital, uses 100 percent outside air. HVAC systems that are designed with 100 percent fresh air supply also benefit from the use of High Efficiency Particle Air (HEPA) rated filters. True HEPA filters must capture at least 99.97 percent of particles that are 0.3 micrometers in size or larger. These filters are commonly used in medical facilities, cleanrooms, and applications where extremely high air quality is essential. The types of hospital environments where the benefit is most useful are operating rooms, intensive care units, clean rooms, decontamination, and medical equipment processing departments, burn and bone marrow transplant units.

Other types of filters called MERV (Minimum Efficiency Reporting Value) are also useful in different critical environments of a healthcare facility.

MERV 8: Often used as a pre-filter, MERV 8 filters capture small particles such as dust and mold spores with little restriction to flow. MERV 12 - 13: Improved filtration, effective against fine particles like smoke and some bacteria.

In summary, EIP technologies, materials, and strategies are adjuncts to cleaning and may be either adjuncts or replacements to traditional disinfection of air, water, and surfaces. Change is quite often slow to happen, but the COVID pandemic has proven that traditional cleaning and disinfection processes do not work well enough by themselves. EIP is therefore part of the 'round' world of new strategies to reduced healthcare and community-based infections and death. Infection prevention is everyone's responsibility, so let us change together and use EIP to the maximum. Our lives depend on it.

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