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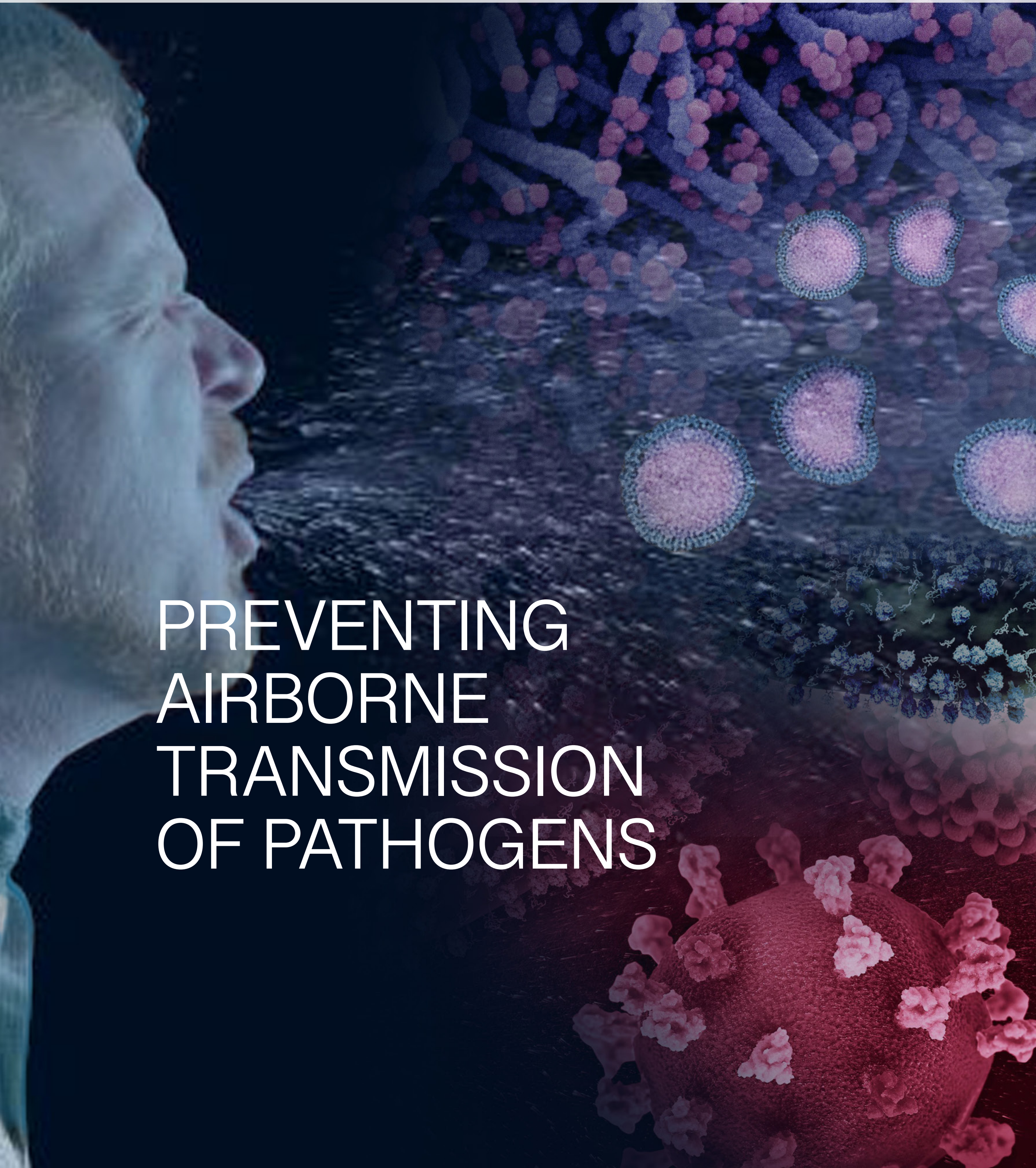

PREVENTING AIRBORNE TRANSMISSION OF PATHOGENS

 

By Richard Dixon and David W. Koenig, PhD

Water Quality and Conservation

> ***"Taken together water is critical for life, critical for pathogen transmission and survival, and critical for infection control. Therefore, it is important to understand water as it enters the healthcare facility and all the forms it can be encountered in that facility."***

Water is vital for life on this planet. Some organisms have up to 90 percent water by body weight. Humans contain up to 60 percent water. Water is also critical in the survival and transmission of pathogens in the healthcare environment. Microorganisms require water to grow and reproduce.

Water requirements for growth are best defined in terms of water activity, aw, of the substrate rather than as water concentration. The water activity of a solution is expressed as aw = P/Po, where P is the water vapor pressure of the solution and Po is the vapor pressure of pure water at the same temperature. Addition of a solute to an aqueous solution in which a microorganism is growing will have the effect of lowering the aw, with a concomitant effect upon cell growth.

Every microorganism has a limiting 'aw' below which it will not grow, e.g., for streptococci, *Klebsiella spp., Escherichia coli, Clostridium*, and *Pseudomonas* spp. the value is 0.95. *Staphylococcus aureus* is the most resistant and can proliferate with an aw as low as 0.86. Some fungi can grow with an aw of 0.7. Therefore, wet environments favor the survival and therefore transmission of pathogens.

Water is also key to the cleaning and disinfection of these surfaces. Cleaners and disinfectants are mostly water-based, either being used as a ready-to-use (RTU) or diluted with water at the point of use. Taken together, water is critical for life, critical for pathogen transmission and survival, and critical for infection control. Therefore, it is important to understand water as it enters the healthcare facility and all the forms it can be encountered in that facility.

Water Quality

In the United States, potable water or drinking water is regulated by the Environmental Protection Agency (EPA). The EPA sets the legal limits on more than 90 chemical and microbial contaminates for drinking water. The EPA mandates that any water treatment technology must meet a disinfectant standard and that the resulting product is free of pathogens.

Although potable water standards ensure safe drinking water, the water is not sterile. Following EPA standards ensures that drinking water has a low probably of containing at risk organisms. The disinfectant is added at the treatment facility and is at a level that allows for preservation of the drinking water through the potable water distribution system to point of use. The level of disinfectant can be relatively low at the point of use, dependent on the demand in the distribution system. The disinfectant added is not sufficient to control contaminates that may be introduced into the distribution system due to breaks in the system. Once the water is removed from the distribution system, that level can decrease rapidly due to demand. Importantly for infection control measures, the design of the building's water distribution system can significantly alter water quality. The water in the building can pass into water heaters, heat exchangers, faucet aerators, and lie stagnant in dead legs before use. Ice machines can be a challenge for microbial control. Furthermore, in older buildings, mixed metals and plastics used in the distribution system due to renovations and building additions can impact mineral build-up and biofilm development. Water systems that are not managed appropriately allow waterborne pathogens to increase in types and numbers resulting in infections in susceptible individuals.

Innovations for optimizing water quality, safety and conservation in a healthcare facility are insightful, forward-thinking, and necessary. By employing a holistic approach to water management, facilities can not only enhance operational efficiency and reduce the cost of the water supply from the local municipality but also contribute to environmental sustainability and, most importantly, patient, staff, physician, and visitor safety. The next sections will review those processes and provide insights in optimizing water usage while reducing pathogen transmission risk.

Water Microbiology: The main risk of bacteria in drinking water is usually due to contamination events that introduce human fecal organisms to the water distribution system. The most common problem organisms associated with drinking water are V*ibrio cholerae, Vibrio parahaemolyticus, Salmonella enterica, Shigella dysenteriae, Shigella flexneri, Shigella boydii, Shigella sonnei, Escherichia coli,* and *Campylobacter* sp. Problem viruses include adenovirus, astrovirus, hepatitis A and E viruses, rotavirus, norovirus, and enteroviruses, including coxsackieviruses and polioviruses. Other bacteria associated with water and infection include *Mycobacterium*, *Legionella, Burkholderia, Klebsessia,* and *Ralstonia*. Fungi can be isolated from tap water distribution systems, but their types and numbers are poorly defined. The most detected fungi are *Aspergillus, Cladosporium and Penicillium*. ***Giardia*** and ***Cryptosporidium*** are the most problematic protozoans found in water systems.

Point-of-Use Water Disinfection Technology

Reactive Oxygen Species (ROS): An innovative method of reducing pathogens in water is the use of point-of-use (POU) of ROS such as superoxide radicals, hydrogen peroxide, and hydroxyl radicals, are molecules that can cause oxidative stress and damage to pathogen cellular components. Water, on the other hand, is a fundamental molecule that supports life and biochemical processes by acting as a solvent and facilitating various reactions within cells but does not kill any bacteria.

Germicidal Ultraviolet Light: The most effective systems are those ultraviolet lights with the C wavelength (UVC) at 254 nanometers, which can easily disinfect the incoming or return water lines.

Copper-Silver Ionization: The proposal of using hot water produced at the central boiler room, treated through a copper/silver ionization system for bacterial control, is a proactive step to ensure safe water distribution. This measure, particularly in combating bacteria like Legionella, is both prudent and necessary for safeguarding the wellbeing of all stakeholders in a healthcare facility.

Hand Hygiene Sinks That Use Ozonated Water: A smart flow sink that uses ozonated water to eliminate bacteria both on hands and on the sink itself is an easy way to eliminate harmful pathogens that collect in the P-trap below hand hygiene sinks. Ozonated water has been shown to be more effective than soap and water for bacterial removal from hands. This sink also provides a source of ozonated water for general cleaning and sanitizing. Convenient and twice as powerful as bleach, the sink is programmed to disinfect itself automatically, every hour, eliminating CPOs (Carbapenem-producing organisms, like Kleb's pneumonia and E. coli) and preventing biofilm formation in the P-trap to prevent CPO outbreaks in a healthcare facility. And the system does not generate ozone into the air.

Engineering and Process Control Steps to Maintain Water Quality

Water Quality Measurement: Incorporating technology to monitor water quality parameters like hardness, pH, and total dissolved solids (TDS) is a crucial step toward ensuring the safety and suitability of water for various purposes. By setting and adhering to quality standards, you're building a foundation for a consistent and reliable water supply throughout the facility.

Eliminate Dead-End Piping: Toward this end, it is important that a healthcare facility identify dead-end piping systems and segregate them from the active water lines. Keep in mind that most water distribution systems flow through copper pipes.

Eliminate Aerators on Sink Faucets: Aerators on sink faucets collect minerals and pathogens so their use should not be allowed on any sink in the healthcare facility.

Eliminate the Traditional P-Trap Under Sinks: An innovative approach to significantly reducing pathogen-containing wet and dry biofilms in a traditional sink P-trap is to eliminate this 140-year-old method of sewer gas control with a straight vertical drainpipe. The sewer gas control is accommodated by using an automated negative-pressure system from the drain piping air vent with exhaust to the facility roof. In addition, gate or ball shut-off valves on the horizontal drain piping can be closed off periodically to have disinfectants poured into the sink drains with an appropriate amount of dwell time to kill the pathogens, and the piping then re-opened back up for regular use. Also, never dump patient medications, fluids, or feces in a sink. Always follow the facility's standard operating procedures for these components.

Ice Machines Cleaning and Disinfection: These units commonly used for producing ice cubes and crushed ice can become contaminated if not properly maintained, cleaned and disinfected. Contamination of ice machines can pose health risks, as the ice produced may encounter harmful microorganisms and impurities. Here are some potential sources of contamination and steps to prevent it:

Microbial Contamination**:** Bacteria, molds, and yeast can grow in the water supply, ice bin, and ice-making components of the machine. These microorganisms can multiply and contaminate the ice cubes.

Prevention: Regularly clean and sanitize the ice machine according to the manufacturer's recommendations. This includes cleaning the ice bin, water lines, and ice-making components. Use approved cleaning agents to eliminate microbial growth. Even better, ultraviolet light systems with the C wavelength (UVC) at 254 nanometers can easily disinfect the incoming water line. Another innovation would be to use modular ozonated water systems. An ozone generator system regularly sanitizes the water supply and kills bacteria, mold, and yeast. It produces an effective but safe amount of natural sanitizer that treats the machine interiors and sanitizes the remote storage bins and drains. No aerosolized ozone is dissipated into the air through this process.

Mineral Buildup: Over time, minerals from the water can accumulate in the ice machine, leading to scale build-up. This can affect the quality of the ice and the efficiency of the machine.

Prevention: Use a water filtration system to reduce mineral content in the water supply. Regularly de-scale the ice machine to remove mineral build-up. Follow the manufacturer's instructions for use and de-scaling procedures plus the frequency.

Cross-Contamination: Improper handling of ice scoops and containers can lead to cross-contamination. If hands, containers, or utensils that are not properly sanitized encounter the ice, it can lead to contamination.

Prevention**:** Train staff in the proper hygiene practices when handling ice. Provide separate scoops for ice and other food items to prevent cross-contamination.

Airborne Contaminants**:** Airborne particles, dust, and debris can enter the ice machine and settle in the ice bin, leading to potential contamination.

Prevention: Keep the ice machine in a clean environment and regularly clean the surrounding area. Use air filters to minimize airborne contaminants entering the machine.

Improper Storage: Storing ice for extended periods without proper protection can lead to contamination from external sources.

Prevention: Use covered ice bins to protect ice from airborne contaminants. Dispose of ice that has been exposed for too long.

Water Quality: Poor water quality, including high levels of impurities or contaminants, can lead to poor-quality ice.

Prevention: Use water filtration and softening systems to improve the quality of the water used in the ice machine.

Inadequate Maintenance: Neglecting regular cleaning, maintenance, and inspection of the ice machine can increase the risk of contamination.

***Prevention*:** Develop a predictive and preventive maintenance schedule and follow the manufacturer's guidelines for cleaning and maintenance. Train staff on proper cleaning procedures

Water Conservation

AI-Driven Efficiency in Water Heating: Integrating artificial intelligence (AI) technology into zone booster heaters to manage hot water distribution effectively is a testament to the facility's commitment to efficiency. By providing hot water precisely where and when it's needed, you not only minimize waste but also optimize energy usage. This thoughtful approach showcases the potential of technology in streamlining resource allocation. This can be achieved by heating the water in the central mechanical room at a lower temperature and using booster heaters at locations where hot water consumption is minimal or varied.

Waste Disposal Systems: A suggestion to eliminate macerator waste disposal systems is well-founded. By replacing processes that contribute to clogging municipal waste filtering systems, you're fostering smoother waste management operations and potentially reducing maintenance costs. This proactive shift reflects a practical and sustainable approach to waste disposal.

Reverse Osmosis (RO) Water: This can be an eco-friendly and cost-effective approach, as RO systems waste a significant amount of water during the filtration process. Here are some ways you can reuse RO water:

- ✓ Landscaping: One of the most common uses for reused RO water is for watering plants and gardens. Since RO water is free from many contaminants, it can be suitable for your plants. Be cautious, however, not to overdo it with sensitive plants, as RO water might lack some minerals that are beneficial for plant growth.
- ✓ Humidifiers and Chillers: Reused RO water can be used in this type of equipment as it doesn't contain minerals that can lead to scaling or deposits in these appliances. RO water for use in cooling towers, allows for less chemical use, and allows water to be re-used for significantly less cycles than municipal water.
- ✓ Waste RO Water: Instead of putting the waste RO water into the sanitary drain system, it can also be disposed of into the storm sewar stream with permission of the local municipality. They also may be able to provide a tax credit using this disposal system as the water that goes into a sanitary system requires municipal processing.
- ✓ Toilets: A very innovative process is to channel RO water for use in toilet flushing.

Compressing Municipal Water Supply: It's a simple fact that along with the volume of water passing through your water meter is a volume of air. The volume of that air will vary as the water pressure fluctuates between static and dynamic pressure. The problem is that more than 99 percent of water meters are measured by volume, regardless of whether that volume is liquid or gas. A smart valve that compresses the municipal water before passing through a facility water meter takes long-established principles of pressure and fluid dynamics, such as Boyle's Law regarding gas pressure and volume, and Le Chatelier's Principle of volumetric dynamics, and applies them in a new and financially rewarding application. This innovative process eliminates most of the air bubbles in the water and thus the volume is reduced and so is the cost.

Leak Detection Technologies: Smart meters and sensors can identify leaks and potential contamination points in water distribution systems, helping to reduce water losses and save money too. Leaks, even small ones, can waste significant amounts of water over time. Implement a proactive leak detection and repair program to fix leaks as soon as they are identified.

Educational Campaigns: Public awareness and education campaigns in the healthcare facility can promote water-saving behaviors and encourage individuals and communities to adopt water-efficient practices.

Water Audits and Monitoring: Conduct regular water audits to identify areas where water is being wasted. Install zone water meters to track usage in different parts of the facility and identify trends or anomalies.

Water-Saving Technologies: Consider installing water-saving technologies such as sensor-operated faucets, dual-flush toilets, and waterless urinals to reduce water usage.

Water Reduction Goals: Establish specific water-reduction goals for your business and track progress regularly. Encourage departments to compete and collaborate on water-saving initiatives. Reward employees who have innovative ideas to conserve water usage.

Regularly Review and Improve Strategies: Continuously monitor and assess your water conservation efforts. Regularly update your water conservation plan to incorporate new technologies and best practices. These innovations, along with healthcare policy support and public engagement, play a vital role in reducing water usage and ensuring the sustainable management of this precious resource. The key to successful water conservation in a healthcare facility is a combination of awareness, efficient technology, employee involvement, and a commitment to continuously improve your practices.

Other practical and novel conservation strategies

- ✓ Rainwater from roofs or parking garage top floors can be reused for landscaping as well if it can be collected into a storage tank.
- ✓ Smart irrigation systems use sensors, weather data, and soil moisture information to optimize irrigation schedules and flow amounts. Low-flow faucets, toilets, and showerheads use less water without sacrificing performance.
- ✓ Smart meters and sensors can identify leaks in water distribution systems, helping to reduce water losses.
- ✓ Public awareness and education campaigns in the healthcare facility can promote water-saving behaviors and encourage individuals and communities to adopt water-efficient practices.
- ✓ Conduct regular water audits to identify areas where water is being wasted by using zone water meters.
- ✓ Even small leaks can waste significant amounts of water over time. Fix all leaks promptly.
- ✓ Consider installing water-saving technologies such as sensor-operated faucets, dual-flush toilets, and waterless urinals to reduce water usage.
- ✓ Establish specific water reduction goals for your facility and track progress regularly.
- ✓ Reward suggestions to employees who have innovative ideas to conserve water usage.
- ✓ Continuously monitor and assess your water conservation efforts.
- ✓ Regularly update your water conservation plan to incorporate new technologies and best practices.

Water quality, safety and conservation can be achieved if we all work together.

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> ***"The COVID-19 pandemic highlighted that strict implementation of impractical guidelines may yield unintended risks to healthcare workers, patients, and healthcare quality. It also demonstrated that providing clear and unambiguous recommendations helps facilitate implementation and adherence."***

been having meetings with groups and organizations that have reached out with concerns and want to provide some additional input. We can't predict where that might lead or what kind of changes those meetings might lead to in the guidance, but we look forward to reviewing all comments."

Despite the concern triggered by the erroneous perception of relaxing PPE requirements, Babcock says the revised guideline "will be a much more streamlined document, providing easier access to the recommendations," Babcock says. "And as we start to work our way through Appendix A and the individual organisms and specific infections, we will be able to update them in real time as we go along, which is a nice change from the prior way that these documents came out, which was essentially 10 years of silence and then boom, we dropped a book on people. In this way we can work through the recommendations in real time and update the guidance in a timelier manner."

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