Environmental Health & Engineering, Inc.

Guide to Infection Prevention through Care of the Healthcare Facility Environment

Introduction

Hospital-acquired infections (HAIs) remain a significant source of concern for healthcare facilities of all types and sizes. While there has been much work to bring down the rates of infection, there's more to be done. The Centers for Disease Control and Prevention report that, on any given day, one of every 31 hospital patients suffers from at least one HAI.

Fortunately, decreases in certain types of HAIs made in recent years points toward effective strategies for further reducing these risks. Evidence indicates that further reducing HAIs depends first and foremost upon a multidisciplinary approach that accounts for both people-focused and environment-focused strategies. Facilities and infection prevention and control departments must partner with and educate one another on their respective areas of expertise to better understand what causes these infections and more effectively how to prevent them.

These teams can further benefit from applying a Source→Pathway→Receptor approach to understanding the potential infection transmission process(es). At a high level, the source-pathway-receptor approach is as simple as it sounds. To better protect the "receptor" (most often the patient), often compromised in some way that makes them more susceptible to infections, greater understanding is needed of the typical sources and pathways of infection transmission. By identifying and regularly surveying these common sources and pathways healthcare facilities can better identify and proactively mitigate potential risks.

In this guide, we'll address some of the types of infections that are caused by environmental hazards and promoted by inadequate infrastructure. While hospitals have begun to improve infection surveillance around certain bacterial and fungal infections, additional risks remain to be addressed. Today's HAI risks include:

- ***Improper airflow and its impact on surrounding areas.*** Appropriate pressurization and ventilation, maintaining appropriate humidity levels and segregating "dirty" areas from "clean" areas, are key to reducing infection risks.

- ***Water stagnation and improper disinfectants and temperatures.*** Having an effective water management plan is crucial for patient safety. However, many hospitals continue to struggle with the development and implementation of a comprehensive water management program.

- ***Construction contamination.*** Healthcare facility renovations or construction projects of any size carry a risk of exposing patients to dust and mold spores, noise, vibrations, odors or chemicals. By understanding the sources and the pathways of these issues, healthcare facilities can better plan to prevent many such problems.

We'll also address some of the areas most severely impacted by these risks, and the evolving understanding of how to mitigate HAIs in these critical care areas.

Understanding how these risks arise is the first step. We'll also address how to involve key stakeholders in addressing environmental sources and pathways to mitigate infection risks. By building a more expansive and knowledgeable team, healthcare facilities of all sizes can take the next step in mitigating HAI risks.

CHAPTER ONE:

Reducing Hospital-Acquired Fungal Infections

The Centers for Disease Control and Prevention (CDC) notes that surgical site infections carry an estimated cost of $3.3 billion each year and are associated with nearly 1 million additional annual inpatient days. Bacteria is by far the most common contributor to surgical site infections, and as a result much surgical site infection surveillance has focused on bacteria. However, fungal infections have been on the rise in recent years.

In general, four types of fungal infections pose a risk to patients:

- **Respiratory infections:** Lung infections are most common in stem cell or solid organ transplant recipients and patients receiving immunosuppressant medications.
- **Invasive *Aspergillus* infection:** This infection often starts in the lungs, but can spread to the brain, kidney, liver and other organs. This fungal infection is of concern for patients who receive immunosuppressant medications or have undergone stem cell or solid organ transplants. This is the deadliest type of fungal infection.
- **Surgical site infections:** Often caused by an exposure to mold in the operating room or recovery environment. This infection occurs at the site of the incision.
- **Cutaneous (skin) infection:** A fungal infection of the skin.

While fungi are intrinsic to all environments, there are clear steps healthcare teams can take to mitigate these risks.

An ubiquitous environmental risk

Mold is ubiquitous to the natural environment. It proliferates within a wide range of temperatures, particularly in humid conditions. Certain fungi, called thermophilic opportunistic fungi, proliferate at temperature conditions found within the human body. Hospital-acquired fungal (mold) infections are caused by these opportunistic fungi within immunocompromised patients. Exposure wouldn't normally cause health problems for the average person, but can be extremely dangerous to hospital patients with weakened immune systems or who have undergone invasive procedures.

The challenge here is that, because mold is a part of all environments, both indoors and outdoors, it's virtually impossible to create a space where there are absolutely no mold spores. As a result, hospitals will have a low incidence of fungal infections that is considered typical or expected, and it's important to know what is normal for their environment. The prevalence of these infections is based on the inherent risk of clinical practice, certain procedures and immunosuppressant medications.

Given that mold is found in most environments, you might expect fairly stringent requirements to reduce this risk in critical areas. However, clinicians and infection prevention personnel are often surprised to discover that, under the code requirements, operating rooms are not even required to have HEPA filters that can capture these problematic airborne particles.

Identifying fungal risks

To mitigate the risk of surgical site infections caused by fungi, facilities departments, infection control preventionists and clinicians should be aware of environmental factors that can increase risk. A Source→Pathway→Receptor approach can help identify causes and pathways of infection.

Common sources and pathways of mold that cause fungal infections in hospitals include:

- **Construction and renovation activities, particularly demolition processes, can disturb contaminated building materials or soil that harbors mold spores.**
- **Water damage, stagnant water or high humidity conditions create an environment that supports mold growth.**
- **HVAC systems can support mold growth within the system itself or move mold spores from the outdoor air inside.**
- **People's clothes and shoes, supplies and equipment brought into a space from outside, or even from an area that does not follow cleaning protocols, can carry mold spores into or through critical spaces.**

Mitigating fungal risks

Understanding the sources of this problem, and how it can travel through the environment to critical spaces, offers the key to preventing and mitigating hospital-acquired fungal infections. These solutions include:

- **Make proactive surveillance methods part of your environmental infection prevention program.** Most hospitals only know they have an increased risk of fungal infections after patients are already sick. Ensure that environmental surveillance rounds include an assessment of evidence of water damage, an interview with staff of high-risk areas about local mold or water intrusion issues, and a review of HVAC preventative maintenance procedures.

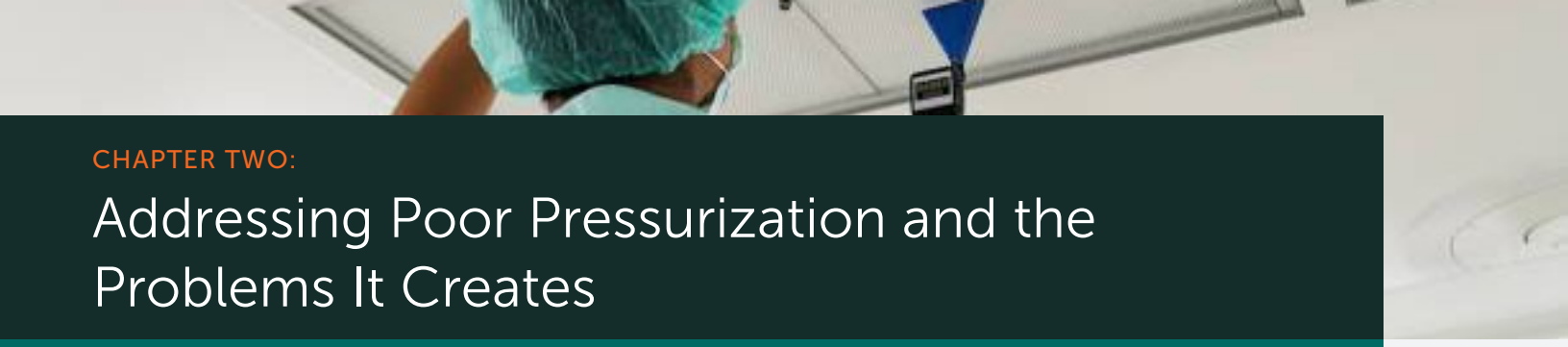
- **Know the risk of construction and renovation.** Take proper precautions prior to renovation and construction activities. Consult with environmental infection control experts to avoid a potential risk of mold exposure to your patients (see chapter 4 for more).

- **Check water sources and humidity levels regularly.** This includes ensuring the humidification and ventilation systems are properly calibrated and all equipment through which water travels or sits is appropriately disinfected. Hospitals should also ensure humidifiers have appropriate controls and investigate "fail-safe" procedures, where the humidifier automatically shutdowns in the event of a malfunction rather than left running to over-humidify the space.

- **Assess the HVAC equipment's filtration system and filter efficiency.** Filters need to be appropriately selected, well-sealed and properly in place to do their job. Schedule periodic preventive maintenance checks and filter changes.

- **Conduct proactive assessments.** Consider taking proactive air samples to assess risk in your highest risk locations to identify potential issues before they result in an infection. At a minimum, this enables you to characterize a baseline of indoor mold spores so any aberrant results are identified before a fungal infection occurs.

Taking these proactive steps can help teams create a more robust strategy for targeting a broad range of potentially infectious HAIs.



CHAPTER TWO:

Addressing Poor Pressurization and the Problems It Creates

Airflow provides an easy pathway upon which potential infection-causing bacteria, viruses, or mold spores can travel. Ensuring proper levels of pressurization is critical in minimizing infection risks.

While healthcare facilities teams understand the importance of pressurization, what is often less well understood is how minor changes in pressurization can impact adjacent areas and adjustments may lead to problems with temperature and humidity. By recognizing the broader impacts of slight changes in room pressurization, facilities teams can more proactively manage this potentially problematic pathway.

Changes in pressurization

Depending on the purpose of the room, or the condition of the patient or equipment contained within it, airflow may need to be directed either into or out of the room. The goal is to either keep infection causing aerosols out or keep them in.

Positive pressurization directs air out of the room. If a patient is immunocompromised, the airflow must be directed out of the room to prevent infection from spreading to the patient during their weakened state. Positive pressurization of pharmacy cleanrooms keeps sterile drugs free of potential infections and reduces infection risks during invasive procedures in operating rooms.

On the other hand, when the patient is a source of infection (i.e., infectious disease), ***negative pressurization*** creates an isolation room by directing the airflow into the room. However, negative pressurization isn't just used to prevent infections from spreading. Another reason a space will need negative pressurization is to control odors, such as coming from soiled utility rooms, or to mitigate infection/chemical risks from hazardous waste rooms, hazardous compounding rooms, dirty equipment, and the like.

It's important to note that, until recently, facilities engineers have thought of space pressurization as a static feature. Rooms were either positively or negatively pressurized. In light of the COVID-19 pandemic, many facilities are developing spaces that can transition between negative and positive pressure, depending on the need at the specific moment in time. As organizations' resiliency continues to increase, this flexibility may be here to stay.

Monitoring pressurization

Because pressurization plays such a critical role in reducing infection, proactive surveillance and maintenance are imperative. The first step is to ensure spaces meet the requirements laid out by American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 170, which has been adopted by the Facility Guidelines Institute (FGI) and establishes the minimum requirements for pressurization for new construction and existing areas.

Facilities teams should also verify the pressure in high-risk areas, such as operating rooms, on a regular basis. While less risky spaces — like a soiled utility room — can be tested on a less frequent basis (think quarterly or semi-annually), it's still best to have routine monitoring systems in place for quick check-ups.

If a room doesn't meet the appropriate pressurization, the first thing to do is identify any gaps, penetrations or holes that may be the culprit for allowing air to flow in an unwanted direction. Often the solution to a drop in pressurization can be solved by something as simple as sealing ceiling penetrations, making sure ceiling tiles are in place, or fixing door sweeps. It's also important to remember that a change in pressure to one area can lead to changes in pressure in adjacent areas as well. Once these solutions have been applied, check the pressure in surrounding rooms.

It's important to educate all staff to alert facilities team members if they notice these small gaps or any indication of a potential problem. Every person involved in ensuring proper pressurization of sensitive areas needs to have a clear understanding of the reasons and the risks of letting a problem go unchecked. Make sure to designate responsibilities clearly and communicate effectively.

Airflow's impact on humidity

Modifying airflow can have other impacts as well. These changes may affect the temperature and the humidity of a room, two factors that are closely intertwined. If you adjust temperature to meet a range for compliance reasons or for occupant preference, you will impact the humidity. If you change humidity, it's going to impact your temperature as well. While people may be quick to address an uncomfortable temperature, however, humidity is less often addressed. The challenge here is that a too-low or -high temperature can be uncomfortable, where as too-low or -high humidity can be dangerous.

Most people know that high humidity can create issues such as mold growth. However, low humidity leads to a range of problems. Low humidity can increase the chances of the static electricity that can ignite flammable materials, such as hand sanitizer, or cause a shock when interacting with certain electrical equipment in the OR.

Low humidity can dry out certain sterile supplies. It can affect the behavior of solvents in medications, or cause them to stick together or crumble. Low humidity has also been proven to increase the transmission of viral particles.

It's important to monitor humidity levels in critical spaces to maintain proper required relative humidity levels, typically within the 30% to 60% relative humidity range. Checking humidity levels regularly and ensuring ventilation and humidification systems are properly calibrated is an important part of minimizing the potential for mold growth or low-humidity problems.

CHAPTER THREE:

Evaluating Waterborne Pathogen Risks

Having an effective water management program has proven critical for minimizing patient exposure to a wide range of dangerous waterborne pathogens. In fact, one CDC study found that approximately 21% of HAIs can be transmitted via water. However, many hospitals have struggled with the development and implementation of a comprehensive water management program.

Pathogens include *Mycobacterium*, which have proven to be problematic in healthcare facility water systems and cause a range of diseases through exposure to wounds and contamination during surgical procedures. *Pseudomonas* bacteria, found in soil and water, is another common pathogen that can be fatal upon infecting immunocompromised patients. The list goes on, but can be dramatically curtailed through an understanding and mitigation of the sources of waterborne pathogens and pathways.

Where you'll find waterborne pathogens

Waterborne bacteria are ubiquitous. They typically grow in stagnant water or water that is between 68 to 124 degrees Fahrenheit, and are commonly found in a variety of water systems such as cooling towers, condenser water systems, storage tanks, showers, faucets, air conditioning units and ice machines. When the growth of this bacteria goes undetected, hospital patients can breathe in airborne mist from water droplets containing the bacteria, leading to a potentially deadly infection.

The first step to addressing these waterborne pathogen risks is understanding common sources and pathways. Stagnant water is a common source of waterborne pathogens in healthcare facilities. This stagnation can occur when water systems experience underuse, such as a rarely used shower in an ICU, or after a wing or facility closure.

The environment also becomes ripe for bacteria growth when water-using systems are not appropriately maintained. For example, ice machines that are not regularly disinfected or adequately maintained can lead to a build-up of biofilm that support bacteria, mold, and other pathogens.

Construction work can lead to sources of stagnant water or become a pathway for such water. Most major construction or renovation projects have to either turn off the water or connect water at some point to a connection that may not have been appropriately disinfected. Further, construction activities may disturb piping systems, resulting in a change in water quality. A pre-construction risk assessment should include waterborne pathogen control mechanisms (see chapter 4 for more).

Building your water management program

Due to the high risk of transmitting HAIs via water, the Centers for Medicare & Medicaid Services (CMS) now require that Medicare-certified healthcare facilities have water management policies and procedures in place. To comply with regulations around waterborne pathogens, this program should refer to ASHRAE 188, the national consensus standard for *Legionella* risk assessment and risk mitigation, and the CDC toolkit *Developing a Water Management Program to Reduce Legionella Growth & Spread in Buildings: A Practical Guide to Implementing Industry Standards*.

> Healthcare systems can develop a plan to proactively mitigate risks and rapidly respond in the event that a problem occurs.

The Joint Commission (TJC) provides further guidance on how to create an effective water management plan through its forthcoming water management program standard for Hospital (HAP), Critical Access Hospital (CAH), and Nursing Care Center (NCC) accreditation programs.

TJC previously had a single requirement: to minimize "pathogenic biological agents in cooling towers, domestic hot- and cold-water systems, and other aerosolizing water systems." TJC has proposed changes to this program that will be effective January 1, 2022, with four Elements of Performance (EP) that include specific requirements outlining TJC expectations for what that program should include. The four EPs require a team or designated individual responsible for:

- **Oversight and implementation of the water management program. The program must include a written plan and diagram of all water supply sources, treatment systems and control measures, processing steps and all end-use points.**
- **Development of specific program components. These include, but are not limited to, a water risk management plan, a plan for addressing stagnant water and water monitoring protocols.**
- **Documenting water monitoring protocols and acceptable ranges for control measures, corrective actions and procedures to follow if measurements fall outside of those ranges and when a probable or confirmed waterborne pathogen case is identified.**
- **Updating and maintaining the program. Updates must address new risks such as changes to the water system that may add hazard points or the addition of new equipment.**

While many healthcare facilities have already been doing some level of these requirements, this more prescriptive update will support stronger enforcement of this program. This indicates it is a high priority for The Joint Commission's future compliance focus.

Build a reliable team of management and subject matter experts

To ensure compliance with this forthcoming requirement, facility managers should take time today to build a knowledgeable water management team. With a multidepartment team in place, healthcare systems can develop a plan to proactively mitigate risks and rapidly respond in the event that a problem occurs. Members may include representatives from engineering, nursing, quality/risk management, and infection control, the medical director of epidemiology, a senior-level support services director, a representative from clinical labs and environmental services, and the facility manager. Within your water management team, you'll need to specifically assign clear rules and responsibilities.

With all of these requirements in place, it's essential to have complete buy-in from each of the staff members involved. Ensure that your entire facility understands why following water management procedures is important in maintaining the health and safety of hospital patients.

CHAPTER FOUR:

Mitigate Sources of Contamination from Healthcare Construction Sites

Healthcare construction and renovation projects inherently carry risk. A facility renovation or construction project of any size carries with it a risk of exposing patients to dust and mold spores, noise, vibrations, odors or chemicals. At best, these disruptions are annoying; at worst, they are dangerous for potentially immunocompromised individuals.

Fortunately, by understanding the sources and the pathways of these problems, and taking appropriate steps to monitor these areas, healthcare facilities can better plan to prevent many typical construction site infection risks.

Common sources and pathways of infection risk

Mechanical systems, ventilation and plumbing are all common sources and pathways of infection-causing contamination from construction. If left unchecked, construction dust and debris can enter HVAC systems and compromise critical environments. As plumbing systems are shut down or repressurized during a construction project, pathogens can be circulated.

One study published in the *International Journal of Environmental Research and Public Health* (Mar. 2020) tracked HAIs following construction and found inadequate building commissioning to be a leading contributor to waterborne disease cases and deaths.

Pathways are often overlooked as a source of problems. Failing to appropriately close off sites, or ignoring "hidden" pathways that can carry airborne microbes, can infect susceptible hosts. Yet the potential impact upon areas adjacent to construction is often overlooked during project design.

The pressurization of areas adjacent to, above, and below a construction site should be considered carefully. It is important to ensure monitoring goes beyond the area under construction and fully extends to all potentially affected areas.

In some cases, even more visible pathways are overlooked. Too often we think of construction as taking place on a single site, without considering the routes that material and debris travel to reach or leave that site. It's important that construction activities prioritize separating "clean" spaces from contaminated routes. This includes designating specific routes for workers, material entry, and debris removal.

A risk management process

To help minimize the dangers of contamination, the CDC requires hospitals to perform a Preconstruction Risk Assessment (PCRA) and an Infection Control Risk Assessment (ICRA). While a PCRA considers all potential impacts to the hospital, an ICRA is meant to identify the specific risks of patient exposure and the impact to adjacent areas. It is critical key stakeholders are involved in the PCRA and ICRA process for each project.

To ensure compliance with this requirement, it's important to perform routine checks of construction site infection risks. Plan to do at least weekly audits of the construction site to ensure ICRA standards are met.

For an extra level of support between these inspections, consider automated risk monitoring tools. Having multiple control measures in place can further minimize the risk of construction site contaminants. By providing advanced warning of a problem, an automated monitoring system can help teams respond to and fix an issue before it negatively impacts patients, while also avoiding construction shutdowns.

Build a knowledgeable team

Having a plan is but the first step. The next step is to engage a multidisciplinary team of infection control and construction stakeholders who can play a role in minimizing infection risks. In addition to facility managers and infection control practitioners, construction sites also have engineers, construction crews, and environmental health and safety officials engaged in site safety.

To keep everyone focused on the importance of infection prevention, consider developing a standardized checklist that prioritizes risk. Make sure every member of your team has the information they need to address each potential risk before a problem occurs.

If at all possible, hire a construction crew with experience working in sensitive areas. For new and experienced healthcare contractors, contractor "report cards" can help prepare teams on what to expect before stepping foot in the healthcare facility. Setting expectations up front and following up with periodic report cards will help keep everyone on the same page with regards to proactive risk management and emergency response.

By being vigilant about communicating with your team, you can build a stronger, more aware group of individuals dedicated to containing construction site risks.

CHAPTER FIVE:

Preventing Biological Contamination in Sterile Compounding Environments

Awareness has grown considerably in the last decade around the challenges of sterile drug compounding. At least some of this awareness can be traced to an event in 2012, when 753 patients across 20 states were diagnosed with a fungal infection after receiving injections of contaminated methylprednisolone acetate (MPA). Of those 753 patients, the CDC reported that 64 patients in nine states died. The resulting nationwide outbreak of fungal meningitis due to contaminated injectable drugs encouraged regulatory authorities to begin to change expectations around pharmaceutical environments.

Certainly, this awareness has driven attention to the need for stronger infection prevention strategies for sterile compounding environments. However, while pharmacists and others who routinely work in these environments may be familiar with the standards regulating these environments, forthcoming regulatory changes will broaden these requirements to include other hospital settings. Facilities managers and infection preventionists will need to become familiar with the requirements that not only keep contamination out of hazardous drug compounding areas, but also prevent hazardous environments from impacting adjacent areas.

New understanding around pressurization

Sterile drug compounding rooms are among the cleanest rooms in the healthcare environment and, as such, have had incredibly strict requirements for infection prevention management. The current version of national consensus standard USP 797, Pharmaceutical Compounding—Sterile Preparations, sets forth requirements for sterile compounding of both hazardous and non-hazardous drugs. This will be split in the future into separate documents: USP 800, which focuses solely on hazardous drugs (sterile and nonsterile and storage and handling); USP 797, which upon its revision will focus solely on nonhazardous sterile environments; and USP 795 for nonhazardous nonsterile environments.

> With proper monitoring processes in place, infection prevention professionals can better identify the root causes of contamination issues

At present, USP 800 is in effect but not fully enforceable due to its conflicts with the hazardous requirements in the current version of USP 797, particularly around requirements for facilities infrastructure. However, this delay simply means that facilities management teams have more time to prepare now for the big changes to come with the inevitable implementation of USP 800.

When it comes to preventing biological contamination, there are two particular changes that facilities staff should be addressing today. First is the fact that the negative pressure requirements for hazardous drug compounding areas will change from a minimum pressure to a range. The challenge with the minimum requirement has been that these sterile spaces can far exceed that minimum, creating new risks due to excessive negative pressurization. To meet the demand for negative pressure, an HVAC system may pull in potentially contaminated air from other areas: through penetrations, past dirty HEPA filters, and anywhere else air is able to flow. Facilities managers can take steps today to more tightly monitor their pressure in preparation for meeting this narrow range.

As we discussed in Chapter 2, pressure is relative. Anytime an adjustment is made to the negative pressure in one room, it impacts the positive pressure in adjacent rooms as well. Bringing pressure down by adjusting supply will change the pressure in other rooms. As a result, it's important to consider pressurization holistically.

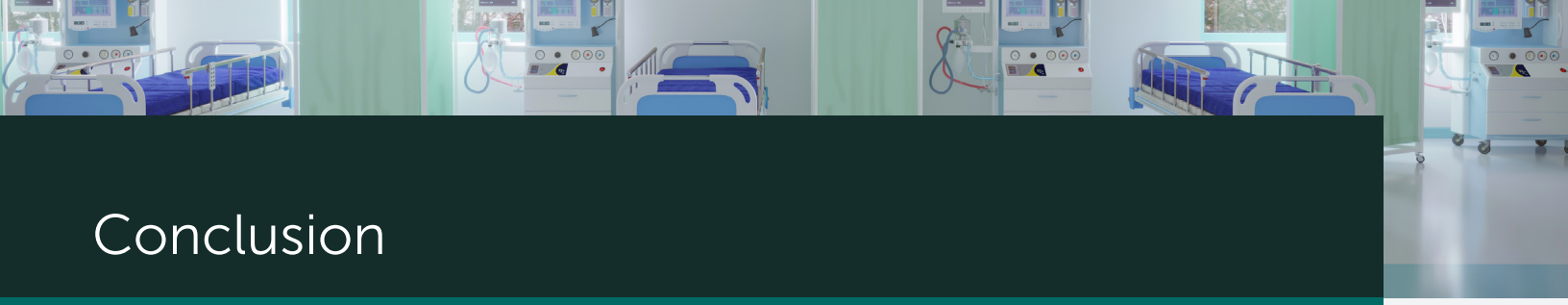
To ensure that these spaces are appropriately pressurized, environmental monitoring must be conducted regularly. Early identification of bio-contaminants is critical for mitigating these infection risks before they cause harm. USP 797 will require monthly surface sampling (is currently semiannual) and semiannual air sampling. With proper monitoring processes in place, infection prevention professionals can better identify the root causes of contamination issues and more quickly act to prevent harm.

A more comprehensive approach to drug handling

The second change impacting facilities managers is the fact that USP 800 now outlines requirements for hazardous drug storage and handling anywhere in the facility. This will most likely affect areas beyond the pharmacy. Achieving hospital-wide compliance with USP 800 may require significant changes around how drugs are transported and stored, and how spills are cleaned and waste disposed.

For example, hospitals may find they need to develop a comprehensive hazardous drug residue sampling program for all areas where hazardous drugs are used. Facilities managers will also want to conduct risk assessments to ensure personnel wear appropriate personal protective equipment when handling any hazardous drugs.

Fortunately, the proposed changes to the facilities-related requirements presented in the revised Chapter USP 797 are unlikely to result in significant changes following this latest review, and USP 800 is already in effect. That means hospitals have insight available today to prepare for these coming changes. A proactive approach to these safety regulations will help facilities managers confidently achieve compliance once all updated regulations are in effect.



Conclusion

Healthcare facilities managers and infection prevention teams have done much to reduce the spread of dangerous and costly HAIs. However, there's still more work to do. It's time to broaden the focus on environmental hazards to include fungal infections and waterborne pathogens as well as bacteria. It's time to expand the teams managing these environmental risks to include everyone operating in the healthcare environment. By building more expansive and knowledgeable teams and developing effective programs, healthcare facilities managers can more proactively mitigate some of the most common sources and pathways of HAI risks.

These proactive measures may require more of an investment in time upfront, but history has ample indications that taking measures today to stem the tide of HAIs tomorrow pays off tremendously. The direct cost of an HAI can range between $1,000 to $50,000 per case, depending upon the type of infection. More broadly, estimates put the annual cost of HAIs to a hospital between $28 to $45 billion .

Proactively managing risks around mechanical and water systems, construction sites and areas where sterile drugs and hazardous drugs are handled will provide a healthier environment for caring for patients.

About Environmental Health & Engineering, Inc.

EH&E specializes in mitigating the infection risks of the physical environment and offers all the required expertise under one roof – environmental infection control specialists, compliance experts and engineers – for highly effective infection prevention programs. Patient infections related to the physical environment are preventable. Our experts help you assess and understand the risks in your hospital and establish programs that mitigate those risks in order to protect patients and staff and to minimize liability to your hospital.

- **Construction Risk Assessment and Monitoring Services**
- **Space Pressurization Assessment for Infection Prevention**
- **Water Management Programs**
- **Pharmacy Cleanroom Environmental Contamination Investigation**
- **Healthcare Acquired Infections (HAIs) Outbreak Investigations**

To find out how EH&E can help you improve infection prevention in your hospital for greater patient safety and reduced hospital risk, contact us!

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