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Controlling healthcare acquired infections in the superbug era.

Why hand hygiene and surface cleaning are not enough.

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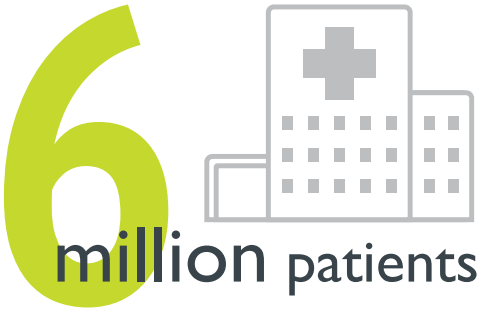
Hospitals today face an acute crisis: the spread of infection among patients.

In high-income countries, 5% to 10% of hospitalized patients — including 30% of patients in intensive care units — contract an infection during their stay.[1] Each year, in Europe[2] and the United States[3], hospital pathogens infect nearly 6 million patients and are responsible for 140,000 deaths. On any given day, more than 1.4 million hospitalized patients around the world[4] and 80,000 in Europe[5] are estimated to have at least one healthcare associated infection; compared to other patients, they may be 80% more likely to die within 90 days.[6] In developing countries, as the World Health Organization (WHO) notes, the childhood death rate from hospital acquired infections equates to "a plane crashing every hour."[7]



Even the cleanest hospitals can serve as breeding grounds for dangerous microbes. Viral particles launched by a sneeze — or by a change of bed linens — hover in the air, to be inhaled by patients or to land on intravenous poles. Pathogens deposited into a box of surgical gloves hitch a ride, via central line, to a patient's bloodstream, or via catheter to the urinary tract. Bacteria travel from the bed rail of an infected patient to the hands of a nurse and from there to vulnerable patients.[8] The web of transmission routes is vast, complex, and invisible.

Pneumonia, meningitis, colitis, gastroenteritis, peritonitis, sepsis — the infections acquired at hospitals can be serious and debilitating. Many turn lethal, or nearly so, because of a parallel crisis: the dramatic increase in antimicrobial resistance. Because of antibiotic misuse, antimicrobial treatment is increasingly difficult and less successful. "We've reached the point where patients are dying of infections in hospitals that we have no antibiotics to treat," cautions Arjun Srinivasan, M.D., associate director for healthcare associated prevention programs at the U.S. Centers for Disease Control.[9]

> "Many healthcare acquired infections turn lethal, or nearly so, because of a parallel crisis: the dramatic increase in antimicrobial resistance."

For hospitals, the costs are staggering:

- Patients who acquire infections from surgery spend, on average, an additional 6.5 days in the hospital and are five times more likely to be readmitted after discharge.[10]
- Those infected by an antimicrobial-resistant pathogen, a.k.a. "superbug," may spend an additional 16.9 days in the hospital.[11]
- A single *methicillin-resistant Staphylococcus aureus* (MRSA) infection in the neonatal intensive care unit can extend the infant's hospital stay by 40 days, at an additional cost of $160,000.[12]

Hospitals are confronting high readmission rates, higher mortality rates, temporary closures due to infection outbreaks, and an alarmed public. Headlines such as "Your Hospital Can Make You Sick" do not inspire confidence.

None of this will come as news to informed hospital staff. But what may surprise even those immersed in

infection control: hand hygiene and surface cleaning, long considered the gold-standard solutions, will not suffice to halt this crisis, even if compliance rates are improved. These strategies, along with strong policies to halt antibiotic misuse, remain as critical as ever, but they also are inherently limited — and, in the superbug era, increasingly inadequate.

"We are trying to solve problems of today with instruments of the past," notes Ojan Assadian, MD, an infectious disease consultant and president of the Austrian Society for Infection Control. "It is time to rethink our approach and combine existing strategies with new technology."[13]

A substantial portion of hospital acquired infections are preventable — including up to 70% of bloodstream infections transmitted by catheter and 55% of ventilator-associated pneumonia and surgical site infections.[14] But to achieve gains, hospitals must become more diligent about preventing infection and more innovative in their approach.

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>
> – **Ojan Assadian,** *MD,*
> *Infectious disease consultant and president of the Austrian Society for Infection Control*

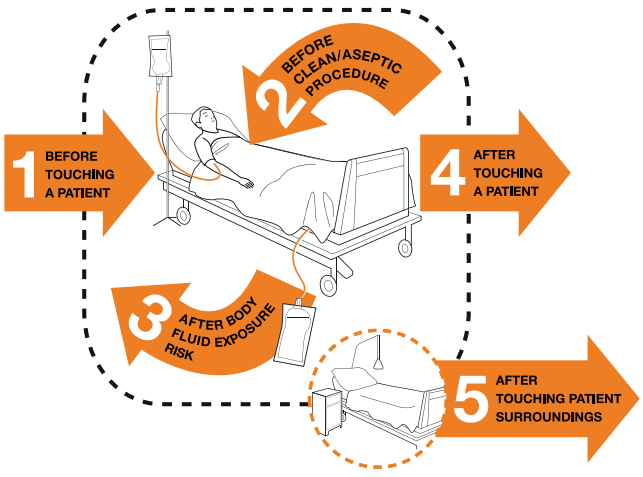
This paper explains the current limitations of hand hygiene and surface cleaning in clinical practice and how a third strategy — air disinfection, to inactivate viable particles before they settle on surfaces — can provide additional protection against the infections that, every day and at every hospital, threaten lives, health, and revenue.

Hand Hygiene Compliance: "The Dirty Hand in the Latex Glove"

Healthcare workers' hands are the chief vehicle for pathogen transmission at hospitals.[15]

Pathogens can proliferate even on intact skin — in the armpit, on the chest and back, around the perineum — and have "an impressive ability to survive on the hands, sometimes for hours," as WHO notes.[16] Accordingly, healthcare workers' hands, whether bare or gloved, can become contaminated even after seemingly "clean" procedures such as taking a pulse or a temperature or touching a patient's groin. Of course, the risk skyrockets when staff change wound dressings, handle a ventilator, or otherwise come in contact with blood, body fluids, or mucous membranes. In a French study, 24% of healthcare workers' hands were contaminated with *Clostridium difficile* spores after routine care of patients infected with the bacteria.[17]

Infection control experts agree hand hygiene is the single most effective way of reducing healthcare associated infections. "During the past 20 years, we have predominantly concentrated on improving compliance," says Prof. Assadian. Building on WHO's "Clean Care is Safer Care" and "My Five Moments for Hand Hygiene" initiatives, countries and regions have launched their own campaigns, such as "STOP! Clean Your Hands" in Canada; "Clean Hands Save Lives" in New South Wales, Australia; and "Germs. Wash Your Hands of Them" in Scotland.



WHO, *Five Moments for Hand Hygiene.*

At every turn, healthcare workers are reminded to squirt enough alcohol-based hand rub, to use paper towels when turning off the faucet, to remove gloves properly, to perform antisepsis between patients and procedures. Training classes, videos, posters, stickers, slogans, voice prompts — hospitals employ all manner of tactics to boost compliance. A Brazilian hospital aired catchy musical parodies over the in-house radio.[18] Scotland's national health service included reminders in staff pay slips, promoting Scotland's "requirement of a zero tolerance approach to non-compliance with hand hygiene."[19]

There's just one problem with the motivational approach: "Realistically," says Prof. Assadian, "it is not sustainable."

Even when hand rub is readily available, when dispensers and sinks are in working order, when policies and procedures are visible, when healthcare workers are reprimanded with "tickets" or enticed with ski passes, compliance remains — to use WHO's term — "abysmally low."[20]

"Even in resource-rich settings," WHO reports, "compliance can be as low as zero percent, with compliance levels most frequently well below 40%."[21]

Study after study finds critical hand-hygiene lapses. Healthcare workers do not rub adequately, use enough hand rub, or clean the back of their hands. They leave their wrists exposed, touch dispensers with their fingers, attempt to disinfect wet hands, or forget to remove wedding rings. They perform clinical work with seriously damaged hand skin and mistake "washing" for "disinfection."[22] As researchers concluded, "Even those workers who fully realize the importance of hand disinfection often do not know in what cases hand disinfection should be carried out unconditionally."[23] Based on observations and questionnaires, the Ukrainian/German team concluded that 76% of health care workers miss at least one key moment, among WHO's "Five Moments," for hand disinfection.

Hand Hygiene Lapses

Much of the documented noncompliance pertains to gloves — for example, healthcare workers will put on wet gloves, remove gloves using an improper technique, or neglect to change gloves when indicated.[24] In a study of six wards at a London hospital, gloves were used inappropriately in 42% of observed episodes, including 92% of low-risk procedures; healthcare workers often failed to remove gloves or to perform hand hygiene after wearing gloves.[25] Other researchers reported similar results: More than 60% of participants did not disinfect their hands before putting on gloves, and 80% disregarded hand disinfection upon taking gloves off.[24]

Proper glove removal is critical, as research demonstrates how easy it is to contaminate skin or clothing upon removing protective gear. In an American study, doctors, nurses, and phlebotomists at four hospitals put on their gloves and gowns in their usual manner, rubbed fluorescent lotion between their hands to simulate dirtied gloves, and then smeared the gloves over their chest and abdomen. After glove removal, black light showed a "contamination" rate of 52.9%.[26]

Hand-hygiene compliance tends to be worse when gloves are worn than when they aren't. A study titled "The Dirty Hand in the Latex Glove,"

conducted at 15 English and Welsh hospitals, found hand hygiene compliance among doctors was 41% when they wore gloves — and 50% when they didn't.[27] Often it is forgotten that gloves will not protect patients but, at best, their wearer. Even then, gloves do not provide complete protection, as pathogens can penetrate small defects in the gloves and can be transferred to hands during glove removal. Testing shows a small percentage of brand-new sterile gloves may harbor defects, and 4% of gloves may become perforated even when healthcare workers wear two pairs.[28] Several researchers have noted that gloves may give healthcare workers a false sense of confidence in protecting patients and themselves."[29]

It is worth noting that healthcare workers may significantly misjudge their hand-hygiene compliance. In a study of eight Hong Kong hospital NICUs, 80% of healthcare workers reported, via questionnaire, that they had followed hand-hygiene guidelines both before and after high-risk situations. But covert observers found just 34% compliance before high-risk situations and 27% compliance afterward.[30]

When staff know they are being observed, several studies show, hand-hygiene compliance typically improves. For example, in a study of five ICUs at two Berlin hospitals, compliance was 29% when healthcare workers did not know they were being watched and 45% when they were told.[31] Yet hand-hygiene habits can become so ingrained that even full knowledge of surveillance may not help. In an American study, healthcare workers who already had demonstrated excellent compliance performed even better when told they would be observed, but among their peers with poor track records, the knowledge did not significantly improve compliance.[32]

Hand-hygiene compliance is difficult to measure — so difficult that the Joint Commission issued a 204-page monograph detailing the obstacles related to study design, observer training, data collection, and more.[33] All of this makes a recent Swiss study of intensive care units particularly compelling. Researchers outfitted nurses and doctors with head-mounted cameras during morning rounds, a study design that allowed for more rigorous monitoring than in-person observation. "We could show for the first time in a fast-paced, real clinical setting how frequently healthcare workers' hands touch surfaces," the authors wrote, "corroborating the fast spread of microorganisms in healthcare settings."[34]

What they found:

- Hands deposit – and likely transmit – potentially harmful microorganisms every 4 seconds onto patients and surfaces.
- The doctors and nurses sustained hand rubbing for a median of 11 seconds, far short of the recommended 20 to 30 seconds.[35]
- Overall, hand hygiene compliance ranged from 1% to 5%.

Partly it is because healthcare workers are human, and like all human beings, they engage in automatic, unconscious behaviors. "People often are unaware of what exactly their hands do while they are focused on the main task goal," the Swiss researchers noted.

The fact that lethal microbes are invisible does not help. "Because we can't see them," one microbiologist observed, "it is easy to forget that they are there."[36]

But hospitals face another large obstacle to improving compliance: healthcare workers are strapped for time. "In our era of budget cuts and reduced healthcare staffing," Prof. Assadian asserts, "it is difficult for healthcare workers to master the art of aseptic and contamination-free patient care. Maintaining perfect compliance, especially during invasive patient-care activities, may not be feasible in this changed healthcare environment."

It is important to note that even 100% hand-hygiene compliance would not solve the problem of pathogen contamination via healthcare workers' hands. In the Ohio glove-and-gown-removal study, skin and clothing were contaminated 30 percent of the time when proper technique was followed.

Hospitals must continue to promote hand hygiene, but they must also know of its significant shortcomings.

The Failures of Surface Cleaning: Superbugs Win

Given the limitations of hospital hand hygiene and the proliferation of superbugs, meticulous surface cleaning is all the more critical.

As Prof. Assadian notes, "The more contaminated the surface, the more likely healthcare workers and patients will pick up bacteria on their hands."

Virulent microbes have remarkable staying power in the hospital environment. *Clostridium difficile* can last 5 months on hospital floors and has been found on shoes of healthcare workers.[37] *Vancomycin-resistant enterococci* (VRE) can survive for up to 58 days on countertops.[38] Noroviruses, tolerant to a broad range of commonly used hospital disinfectants, can survive on carpets for up to 12 days.[39]

It is no wonder patients have a 40% elevated risk of contracting an infection when they stay in rooms previously occupied by infected patients.[40] American research conducted on 23 hospitals shows that

following terminal disinfection of a room, over 50% of surfaces are missed completely during manual cleaning. And whereas the study found sinks, toilet seats, and tray tables were relatively well cleaned, with an average rate over 75%, cleaning rates fell below 30% for toilet handles, bedpan cleaners, light switches, and door knobs.[41] In a different study, the same lead author determined that 40% of high-touch surfaces sampled were inadequately disinfected.[42]

Microbes accumulate 24 hours a day, as visitors, staff, and medical devices come and go. Humidifiers, stethoscopes, supply carts, wheelchairs, stretchers, glucometers, IV poles, portable computers — all can serve as vectors for transmission when even minor flaws in surface cleaning occur. "The danger extends far beyond the handful of patients who stay in that room, spreading from room to room to potentially affect the entire facility," Cornell University researchers warn.[43]

Medical devices considered at low risk for transferring infection, such as blood pressure cuffs and oximetry sensors, may actually pose a greater risk than invasive instruments because they are used on so many patients. "The laryngoscope blade is likely less of a problem than the handle," cautions Janet Haas, DNSc, Director of Infection Prevention and Control at New York Medical College.[44]

To fight surface hazards in the superbug era, many hospitals have raised cleaning standards. They use microfiber mopping systems, remove isolation-room curtains for cleaning, and disinfect toilet handles, bathroom doors, call buttons, tray tables, light switches, and other bacteria-laden surfaces. Despite these efforts, hospital surface cleaning remains inadequate.

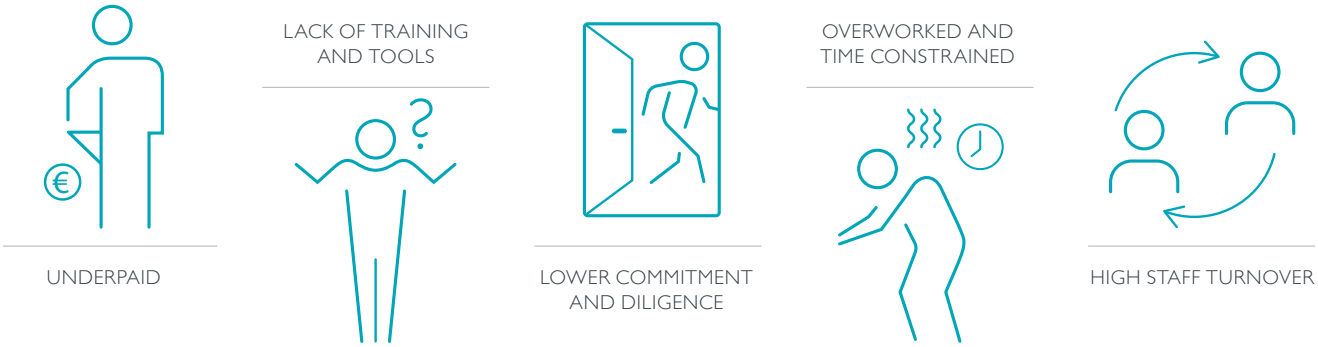
One culprit: the global phenomenon of outsourced cleaning.

In response to financial crises, "hospitals have gutted cleaning staff," writes University of Toronto sociologist Dan Zuberi, Ph.D., author of *Cleaning Up: How Hospital Outsourcing is Hurting Workers and Endangering Patients*. Zuberi spent three years tracking hospital cleaners in British Columbia, where legislation prompted all hospital cleaning to be outsourced. Zuberi calls the change a "disaster," both for cleaners and patients.[45]

Research shows private cleaning crews tend to be underpaid and undertrained, feel less committed to the hospitals they service, perform their jobs with less diligence, face higher workloads, and experience high turnover rates. Problems that arise do not get addressed in person, on the spot; instead, they are funneled through third-party staffing managers who work remotely.

Numerous studies have linked outsourced cleaning to higher rates of infection. Among 126 English NHS hospitals studied, for example, those using outsourced cleaners reported nearly 50% more MRSA infections than hospitals with in-house cleaners. "Contracting out NHS services may save money, but this is at the price of increasing risks to patients' health," wrote study co-author David

Common Problems with Outsourced Cleaners



Often, outsourced staff aren't given sufficient time to do their jobs. "Basically, you do the big stuff, and then you start cutting corners," one hospital cleaner told Zuberi. "You just cannot get it all done. When I say 'cutting corners,' that means bathrooms, offices, hallways. Stuff gets missed." Hospital rooms may be cleaned for half the time as a typical hotel room, Zuberi asserts. Not all rooms are cleaned daily.

What's more, not all surfaces are cleaned thoroughly — with the right chemicals, in the right concentrations, and for the right length of time. "Cleaners do not know how to get surfaces microbially safe – it's just superficial," says Prof. Assadian. They may not fully understand the difference between cleaning and disinfecting; after all, a toilet cleaned in 2 minutes may appear sparkling but remain teeming with pathogens.

> "Cleaners do not know how to get surfaces microbially safe – it's just superficial."

Stuckler, PhD, MPH, a public health expert at the London School of Hygiene and Tropical Medicine. "When these full costs are taken into account, contracting may prove to be a false economy."[46]

American researchers explored the same territory in a paper titled "Superbugs Versus Outsourced Cleaners."[47] Their conclusion: superbugs win.

Their study of California hospitals found "strong evidence" linking outsourced cleaning to incidence of *C. difficile*, a bacterium that can form spores that

linger on sheets, floors, and toilets and is readily spread via equipment and human hands. In this study, 73% of hospitals that did not outsource cleaning reported *C. difficile* cases in the year studied. But among hospitals that outsourced much of their cleaning, *C. difficile* infection incidence reached 91%.

The California study underscores a second reason hospital surface cleaning falls short: Even when it's done right — when standards are high and in-house cleaning crews are motivated, well trained, and well paid — cleaning cannot wipe out pathogens for long. As anyone with a kitchen knows, "clean" is a temporary condition.

In a study of a medical intensive care unit (MICU) in South Carolina, 36 bed rails were sampled for bacteria immediately before cleaning with two different hospital-approved disinfectants and checked at four intervals afterward. One disinfectant was more effective than the other, but in both cases, within 3 hours of disinfection, the bacterial burdens had rebounded to unacceptable levels.[48]

"Our study suggests that cleaning approximately every 2 hours would be necessary to maintain the population of this pathogen at the proposed non-detectable level," the researchers concluded.

This is no small finding, as bed rails are the most contaminated surfaces in a hospital room,[49] and dangerous microbes are easily transferred from bed rails to healthcare workers' hands. A study conducted in Chicago, for example, found VRE bacteria were transferred to gloved hands nearly half of the time after contact with bed rails. In fact,

> "Bacterial levels rebound on surfaces within 3 hours of disinfection."

healthcare workers were almost as likely to have contaminated their hands or gloves after touching objects in a patient's room as after touching infected patients themselves.[50] And transfer of VRE happens quickly: 46% of handprint cultures grew VRE after 5 seconds of contact with the bed rail or side table in a patient's room.

It goes without saying that no hospital can afford to disinfect bed rails 12 times a day.

The Missing Link: Air Disinfection

Inactivating viable airborne particles before they settle on surfaces can provide additional protection against infections.

Dozens of strategies show promise for improving hand hygiene. Among them: rewarding healthcare workers for better compliance, electronic monitoring of hygiene practices, and presenting healthcare workers with real-life, personal stories demonstrating the human cost of hospital acquired infections. The solutions for halting surface transmission are varied, too, and include placing more patients in single rooms,[51] installing copper bed rails,[52] dispatching dedicated cleaning teams to high-risk areas, applying fluorescent products to surfaces for better oversight, and shifting to single-use EKG leads, blood pressure cuffs, and other devices for patients with poor skin integrity.

But these and other strategies are costly, subject to red tape, and unlikely to make an immediate impact on infection rates.

As one research team noted, "Improving hand hygiene involves changing a habit, and it takes time to obtain a sustained improvement." It also takes time — about a decade — to develop new antibiotics. Already, 70% of bacteria have developed resistance to antibiotics[53]; when one superbug is vanquished, two new superbugs surface.

Hospitals don't have the luxury of time or unlimited budgets.

As healthcare facilities work toward improved hand hygiene, surface control, and antibiotic management, Prof. Assadian asserts, "there is a very strong argument to also think about additional options."

Among the most encouraging options: using air disinfection to inactivate potentially dangerous particles before they settle on surfaces and colonize filters.

It is impossible to know what percentage of hospital acquired infections are transmitted through the air, but "strong and sufficient evidence" implicates airborne spread of pathogens — MRSA, *Acinetobacter, Clostridium difficile*, influenza, and norovirus among them — in the current crisis.[54 55] "Airborne transmission of infectious disease," one research team has noted, "is a major public health concern."[56]

Vomiting, coughing, even talking can release infectious microbes into the air. Conversation in the operating room can increase the bacterial load of air and contaminate the facemasks of surgeons and nurses; the greater the crowd in the OR, one study found, the greater number of microspheres detected in a simulated wound.[57]

> "Conversation in the operating room can increase the bacterial load of air and contaminate the facemasks of surgeons and nurses."

Mere breathing can release infectious microbes into the air. An American study found medical providers within 6 feet of influenza-infected patients can be exposed to infectious doses of the virus.[58] Smaller, lighter particles can waft in the air for hours and travel long distances via air currents, while larger particles settle on surfaces. A single infected patient walking to a hallway bathroom can pose a significant threat.

Pathogens are not just propelled into the air by sick patients; they are also carried into hospitals on the clothing and bodies of visitors and staff and swept via air currents into emergency entrances, lobbies, corridors, stairwells, and patient rooms.

Bed spacing, patient isolation, promotion of patient cough etiquette — measures like these can only do so much to minimize the airborne spread of infectious microbes. Not only do few hospital wards have enough rooms to accommodate all infected patients, but staff tend to prop doors open so they can more easily monitor isolated patients.[59]

In most cases, it is simply impossible to separate infected patients from vulnerable patients. That's why it is important to disinfect the air they share.

Appreciating this reality, hospitals deploy air ventilation, filtration, and sanitization solutions. But all of these approaches have limitations.

Ventilation systems must be well maintained to achieve and sustain the required air-change rate, but when maintenance lags — when filters clog or ducts

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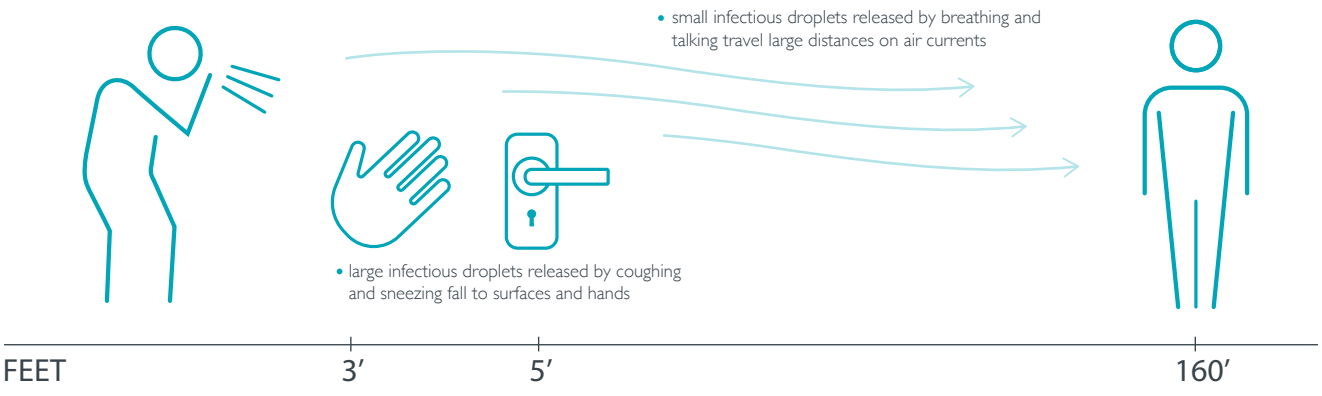

leak — the result is a build-up of the very pathogens these systems were designed to remove. "Poorly maintained ventilation systems may eventually act as a source of, rather than a defence against, aerosol/airborne infection," concluded a University College London study.[60]

Attaining uniform airflow is also a challenge. Consider a large ICU that could be the size of a basketball gym. Air flow through the unit is rarely constant, due to the uneven placement of vents and the way beds are partitioned. Movement of staff, visitors, access doors, and privacy curtains also can influence air currents, dispersing pathogen-bearing particles throughout the space. Even common areas require careful attention to airflow. As one research team noted, ventilation in communal areas such as cafeterias and corridors plays "an important role in maintaining a steady exchange of clean air for potentially contaminated air."[61]

> "Filters only trap pathogens; they don't kill them."

HEPA filtration is often thought of as the gold-standard in air purification. But filters only trap pathogens; they don't kill them. Viable pathogens caught in a HEPA filter can colonize, presenting a safety hazard for maintenance staff who are handling the filters and others who may be exposed during the disposal process.

Aggressive air-sanitization methods such as UV can promote the formation of cataracts and other eye conditions,[62] while misting hydrogen peroxide can irritate or burn the skin and corrode surfaces and instruments. What's more, the sanitization effect of these "point-in-time" solutions is temporary; bioburden multiplies as soon as people begin introducing bacteria and pathogens from hallways, common areas, and the outdoors.

But effective air disinfection need not involve chemicals. An alternate strategy — one that operates continuously — deploys ultra-low energy plasma technology to destroy airborne pathogens on contact. The technology is safe for continuous use around vulnerable patients and staff and is proven to destroy airborne pathogens on contact. This solution can be easily mobilized in high-risk situations like surgeries or operated continuously in large patient wards, ICUs, emergency rooms, and IVF labs.

For numerous European hospitals, ultra low-energy plasma technology has become an effective weapon in the fight against healthcare acquired infections, augmenting hand hygiene, surface cleaning, air ventilation, filtration, and sanitization. As infections become more difficult to treat, healthcare facilities must work to destroy pathogens before they colonize filters or land on the lab coats, surgical gloves, bed rails, and other surfaces that serve as conveyor belts for infection.

Learn more about ultra-low energy plasma technology at **www.novaerus1050.com**

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