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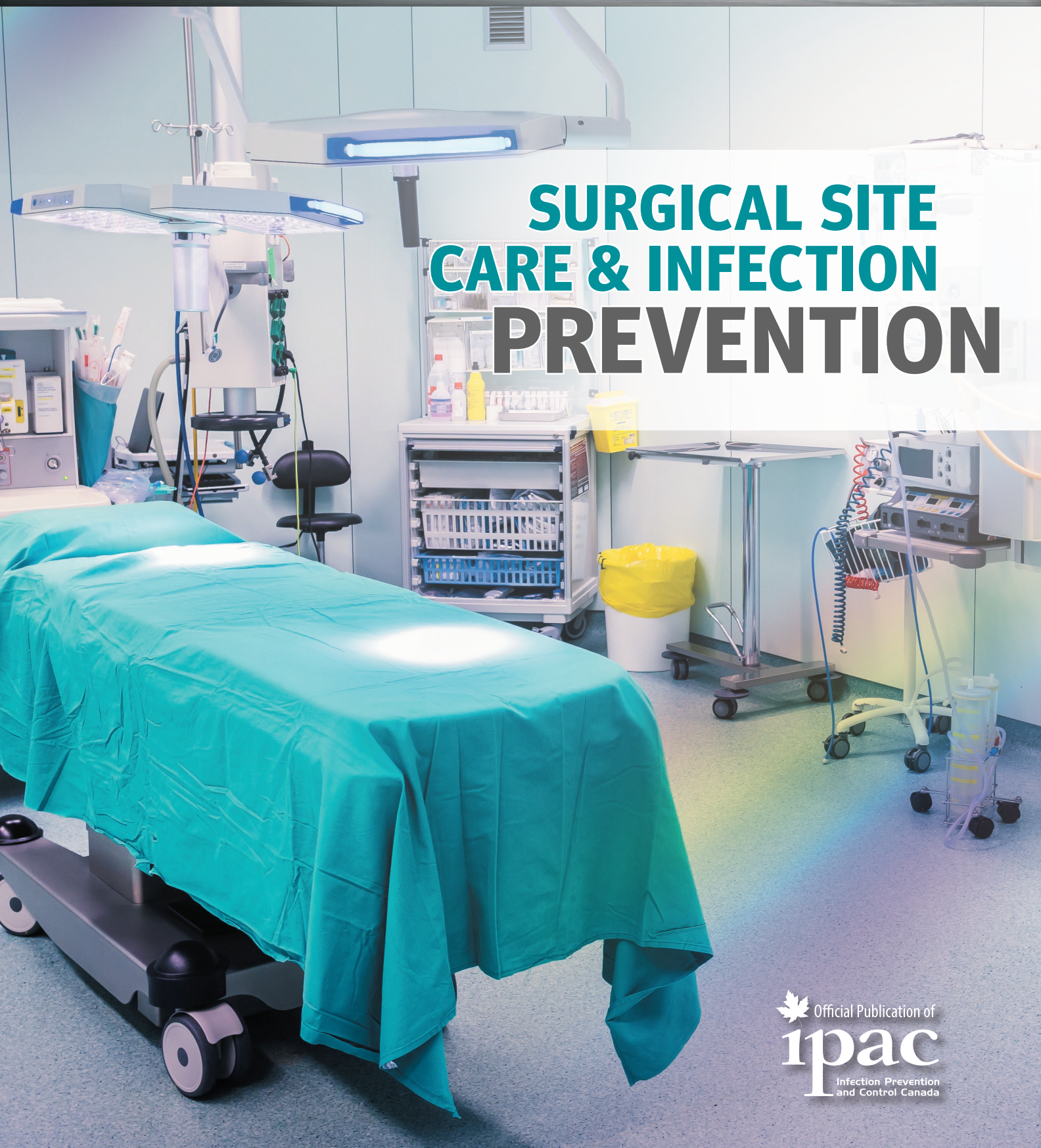
Volume 6, Number 1, Summer 2024



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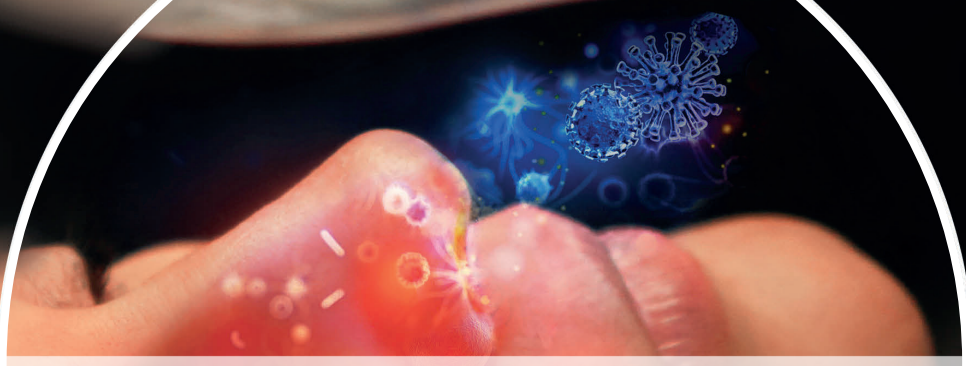

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Foreword

" The wellbeing and psychological safety of our community depends on our ability to uplift one another and find ways to appreciate the daily excellence you bring to your patients and colleagues."

It is with great pleasure that we welcome the IPAC community of practice to the 2024 Summer issue of *Industry Innovations*! When I was asked to serve as guest editor for the *Industry Innovations* issue focused on surgical site infection (SSI) prevention, I was thrilled: SSI prevention is dear to my heart. Many years ago, Dr. Elizabeth Bryce, who is a cherished mentor, had recruited me as a trainee to work on an SSI prevention innovation project, and shortly thereafter, I found myself happily entrenched in the IPAC world and have not looked back. I may not be in the field had it not been for innovation research in SSI prevention!

In this issue, we will explore how industry partners have expanded on crucial learnings from the COVID-19 pandemic, and how they are enhancing existing IPAC strategies and technologies. Notably, clean air in healthcare settings became a priority focus for many institutions during the pandemic, and we continue to evolve our understanding and strategies to mitigate pathogens that transmit through the air. One technology offers a modern, clean-air solution for operating theatres, advancing on the principles of laminar air flow and high-efficiency particulate air filtration. There also continues to be a need for safe and effective disinfection strategies to supplement manual cleaning against respiratory viruses, and importantly, the many antibiotic-resistant threats that pose a significant challenge to the management of patients within our healthcare system.

Finally, we will explore a technology that promises to strengthen an integral part of all IPAC programs: hand hygiene practice and compliance. By combining artificial intelligence and gamification, this technology could prove to be an exciting way to engage healthcare providers in conversations about safety. I'm confident that the innovations and emerging technologies in this issue will be impactful for your IPAC programs, and more importantly, contribute to the safety of your patients.

A final word: as our IPAC communities of practice continue to reflect, reassess and rebuild safety structures in a post-pandemic world, we are reminded of the importance of patience, compassion and simple acts of kindness in our everyday work. The wellbeing and psychological safety of our community depends on our ability to uplift one another and find ways to appreciate the daily excellence you bring to your patients and colleagues. No one understands the sacrifices and challenges we went through as a community as well as we do, so I humbly encourage you to find every opportunity to appreciate and thank one another.

If you're reading this, thank you for everything you've done and continue to do to promote a culture of safety at work and beyond.

Titus Wong, MD, MHSc, FRCPC
Guest Editor, *Industry Innovations* ■

STERIS

Clean Air in the Operating Room

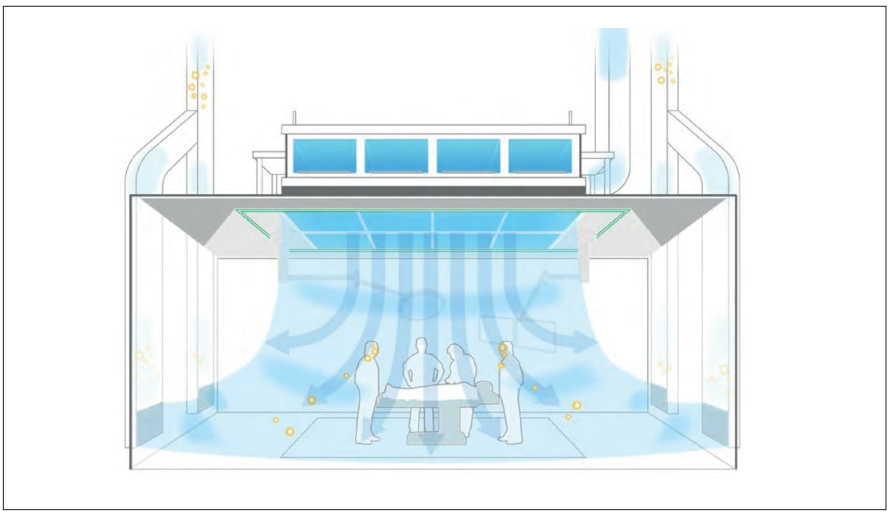
Lena Fogle, BSN, RN, CNOR

More than 16 million operative procedures occur each year in the United States. Prevalence studies show that surgical site infections (SSIs) are one of the most common healthcare-associated infections (HAIs) with estimations of greater than 157,000 SSIs occurring yearly (Magill).

Surgical site infections prolong hospitalization, cause 13,000 deaths annually and can cost up to $29,000 per infection according to the Centers for Disease Control and Prevention (CDC).

Driving Forces in Healthcare

The focus of healthcare has shifted towards monitoring and improving clinical outcomes as Medicare and Medicaid have developed guidelines that deny reimbursement for preventable complications, including surgical site infections. Hospitals are required to report patient outcomes and provide measurable, evidenced-based, quality improvement initiatives designed to improve clinical outcomes. Surgical site infections are largely preventable. The current focus on the prevention of surgical site infections is driven primarily by patient outcome improvement and secondarily by the way hospitals are reimbursed from CMS, and the focus of the Accountable Care Act on the value-based quality of care provided to the surgical patient.



Sources of Contamination

There are many ways in which pathogens may contaminate the surgical field, potentially resulting in a surgical site infection. Contamination sources in the operating room are numerous and may include equipment, instruments, the surgical team, operating room traffic, and air quality in the operating room. Published clinical studies and professional organizations such as AORN agree that airborne squames, or skin scale particles, shed from the patient and personnel in the operating room are the primary source of bacteria that cause infections in the surgical suite (Woods et al, Knobben 2006).

Optimizing the Quality of Air in the OR

Airflow control is one way to decrease the number of potential pathogens introduced into the surgical site. Clinical studies have demonstrated a strong linear relationship between the level of bacteria in the air and the prevalence of a deep SSI (Andersson et al. 2012). Airborne bacteria levels are measured as colony-forming units per cubic meter (CFU/m^3), and each CFU will contain between 1 and 1,000 particles of bacteria.

Studies have shown a significant correlation between increased personnel in the operating room and increased bacterial counts or CFU/m at the surgical site, indicating that CFUs may also be

originating from peripheral personnel in the operating room (Stock 2010).

Laminar airflow systems are designed to provide highly filtered air with continuous air exchanges to reduce airborne particles. Laminar airflow ventilation systems greatly reduce the levels of airborne contamination with a reduction of 89% in CFUs over displacement systems (Andersson et. al 2014). Literature reviewed by Howard and Hansseen determined that vertical laminar airflow is more effective than horizontal airflow. People or equipment passing or standing between horizontal airflow wall units and the patient disrupt the air flow, decreasing the effectiveness of the system. In contrast, vertical laminar airflow, coming from the ceiling, shows a significant reduction in the number of microorganisms on the instrument table and the surgical field (Hansseen, 2007). The CLEANSUITE® System is a vertical ceiling laminar airflow system which directs airborne particles away from the surgical field and the patient on the operating room table, preventing entrapment of airborne particles around the surgical site.

Filtering Out Contaminants

High-efficiency particulate air (HEPA) filters are designed to filter out airborne particles. Multiple studies conclude that operating rooms with HEPA filtration systems have lower levels of microbial and Aspergillus contamination (Crimi 2009), and reduced levels of particulate matter (Wan 2011). A comparative study measuring airborne microbial concentrations found fungal concentration levels to be lower in operating rooms with HEPA filters (Perdelli 2006). HEPA-filtered air minimizes the recirculation of contaminants in the surgical suite, reducing air microbial loads (Aydin 2013). The CLEANSUITE System uses HEPA filters to significantly reduce levels of particulate matter in the air, bathing the patient and surgical area with lower levels of contaminants.

Minimize Turbulence

Ventilation systems with the greatest efficiency at preventing particle emission into the sterile field are systems that provide low-turbulence displacement airflow with flow stabilizers (Hirsch 2012). The CLEANSUITE System has equalizers that stabilize and balance the airflow which can be adjusted with filters in place. This laminar airflow system maximizes the surface area of the ceiling space, ultimately forming a single large diffuser over the surgical area. The CleanScreen™ laminar flow diffuser optimizes laminar airflow to the operating table by providing unidirectional airflow that minimizes turbulence, provides optimized airflow particle containment, and produces predictable movement of particles away from the sterile field.

CLEANSUITE System Offers Wall to Wall Laminar Air

A study compared no laminar flow systems to use of laminar airflow in 80 orthopedic surgical procedures completed by Diab- Elschahawi found a significant reduction in the number of microorganisms on the instrument table and an insignificant reduction

Publication Title	Key Findings	Relevance to CLEANSUITE System
Howard J. L., Hanseen A. D. (2007). Principles of a clean operating room environment. *Journal of Arthroplasty. 22,* 6-11.	Vertical laminar airflow is more effective than horizontal.	Vertical laminar airflow significantly reduces the number of microorganisms around the surgical field.
Stocks, G. W., Self, S. D., Thompson, B., Adame, X. A., O'Connor, D. P. (2010). Predicting bacterial populations based on airborne particulates: A study performed in non-laminar flow operating rooms during joint arthroplasty surgery. Association for Professionals in Infection Control and Epidemiology, Inc., *38*, 199-204.	Airborne bacteria in the operating room demonstrated a correlation with postoperative infection at the surgical site and deep within the wound. Airborne bacteria cluster together forming particles measuring 4 µm – 20 µm.	CLEANSUITE System satisfies ISO Class 5 standards and filters bacteria measuring ≥ 0.5 µm with extremely controlled well defined ranges for airborne contamination numbers.
Knobben, B. A., Van Horn, J. R., Van Der Mei H. C., Brusscher, H. J., Evaluation of measures to decrease intra-operative bacterial contamination in orthopedic implant surgery. *Journal Hospital Infection 2006; 62:*174-80.	Potential source of contamination is the air in the operating room with airborne bacteria deposition in surgical wounds.	CLEANSUITE System is a laminar airflow system that provides uniform directional airflow that filters out contaminants
Der Tavitian, J., Ong, S. M, Taub, N.A., Taylor, G. J. (2003). Body-exhaust suite versus occlusive clothing: A randomized, prospective trial using air and wound bacterial counts. *Journal of Bone and Joint Surgery. 85,*490-494.	Bacteria generally are larger than ≥ 1 µm and cluster together forming particles that measure 4µm – 20 µm.	CLEANSUITE System satisfies ISO Class 5 standards and filters bacteria measuring ≥ 0.5 µm with extremely controlled well defined ranges for airborne contamination numbers.
Andersson, A. E., Bergh, I, Karlsson, J., Eriksson, B.I. Nilsson, K. (2012). Traffic flow in the operating room: An explorative and descriptive study on air quality during orthopedic trauma implant surgery. *American Journal of Infection Control. 40,*750-755.	Clinical benefits can be expected when reducing airborne contamination levels to 1 CFU/m3 with strong linear relationship between the level of bacteria in the air and the prevalence of a deep SSI.	CLEANSUITE System satisfies ISO Class 5 standards and filters bacteria measuring ≥ 0.5 µm with extremely controlled well defined ranges for airborne contamination numbers.

Publication Title	Key Findings	Relevance to CLEANSUITE System
Wan G. H., Chung, F. F.,Tang, C. S. (2011). Long- term surveillance of air quality in medical center operating rooms. *American Journal of Infection Control. 39*(4), 302-308.	Air quality of ORs having significantly reduced levels of contamination CFU/m3 were rooms with HEPA filtration systems.	CLEANSUITE System is a laminar air system with HEPA filters.
Anderson, A., E., Petzold, M., Bergh, I., Karlsson, J., Eriksson, B. I., Nilsson, K. (2014). Comparison between mixed and laminar airflow systems in operating rooms and the influence of human factors: Experiences from a Swedish orthopedic center. *American Journal of Infection Control. 42*,665-669.	Laminar airflow-ventilation systems have a reduction of 89% in CFUs in comparison with displacement systems.	CLEANSUITE System is a laminar airflow system that provides uniform directional airflow that filters out contaminates.
Crimi, P., Valgiusti, M. Macrine, G. e al. (2009). Evaluation of microbial contamination of air in two hematology departments equipped with ventilation systems with different filtration devices. *Journal of Preventative Medicine Hygiene. 50*,33-36	Incoming air filtered with HEPA filters had lower amounts of bacterial and *Aspergillus contamination*.	CLEANSUITE System uses HEPA filtration to optimize the air quality in the operating room.
Perdelli, F., Cristina, M.L., Sartine, M. et al. (2006). Fungal contamination in hospital environments. *Infection Control Hospital Epidemiology. 27*,44-47	Operating rooms with HEPA filters had lower levels of fungal recovery than areas without HEPA filters.	CLEANSUITE System uses HEPA filtration to optimize the air quality in the operating room.
Aydin, C. N., Ucar, F. B., Haliki Uztan, A., Corbaci, C., Akpinar, O. (2013). Determination and comparison of microbial loads in atmospheres of two hospitals in Izmir, Turkey. *Annals of Agricultural and Environmental Medicine. 20,*106-110.	Filtered air minimizes the recirculation of contaminants within the perioperative area, HEPA filtration systems reduce the air microbial load.	CLEANSUITE System uses HEPA filtration to optimize the air quality in the operating room.
Hirsch, T., Hubert, H., Fischer, S., et al. (2012). Bacterial burden in the operating room: Impact of airflow systems. *American Journal of Infection Control. 40*,228-232.	Low-turbulence displacement airflow with flow stabilizers systems were found to be the most efficient in preventing bacterial emission into the sterile field.	CLEANSUITE System has equalizers that stabilize and balance the airflow.
Diab-Elschahawi M., Berger J., Blacky A., (2011). Impact of different-sized laminar air flow verses no laminar air flow on bacterial counts in the operating room during orthopedic surgery. *American Journal Infection Control. 39*(7),25-29.	Laminar flow system provided a significant reduction in the number of viable microorganisms on the instrument table, and an insignificant reduction of microorganisms on other locations, including the area around the patient's head, the instrument table and the back table.	CLEANSUITE System is a customizable modular system with the ability to provide laminar air-flow over the back tables and instrument tables. As well as the ability to offer wall to wall coverage of laminar air.

of microorganisms on other locations measured in the room, such as the back tables and implant tables. The CLEANSUITE System is modular, with the ability to custom build each surgical suite. The CLEANSUITE System can be built to cover back tables and implant tables, with the ability to offer wall-to-wall coverage, directing airborne particles away from all sterile surfaces, blanketing your back and implant tables with HEPA-filtered air.

CLEANSUITE System Bringing Advanced Technology to the Operating Room

Current regulations govern temperature, humidity, air pressure, and the rate of air exchanges in operating rooms. There are no regulations on airborne contamination levels, however, a widely accepted level of airborne microbes is < 10 CFU/m^3 (Stocks, 2010). Clinical studies show clinical benefits can be expected when reducing contamination levels to 1 CFU/m^3 (Andersson *et al* 2012).

The CLEANSUITE System was developed to meet ISO Class 5 standards and maintains extremely well-controlled, defined ranges of airborne contamination.

Implementing Technology

Companies that manufacture pharmaceuticals, semiconductors and other sensitive products must adhere to strict industry and federal standards on airflow requirements that limits the level of particle contaminants. These industries, by complying with ISO 14644 cleanroom standards, decreased product loss as a result of a failure to meet air quality standards in sensitive environments. In general, bacterial particles are ≥ 1µm in size and tend to bunch together, forming larger clusters of airborne bacteria containing between 1 and 1,000 microorganisms.

The CLEANSUITE System complies with ISO Class 5 cleanroom standards to decrease airborne contamination, filtering out particles that are significantly smaller measuring ≥ 0.5 µm.

The CLEANSUITE System has taken the technology that was established for these clean room environments and has moved it into the operating room, an area that contains multiple airborne contaminants, including bacteria and fungi. The CLEANSUITE System directs airborne particles away from the surgical site, by providing uniform directional HEPA-filtered airflow that moves the particles away from the surgical field and contains them via filtered return ducts. The CLEANSUITE laminar airflow system provides an added benefit of contamination control with the CleanScreen diffuser which optimizes airflow to a unidirectional movement with minimal turbulence creating a cleanroom environment for the operating room.

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EDITOR'S NOTE: While this white paper provides timely information on an important topic, readers are advised that the data, references, and findings within this paper have not been fully verified or endorsed by *Industry Innovations*.

Antimicrobial Photodisinfection Therapy: Essential Technology for Infection Control

Nicolas G. Loebel, Ph.D[1] , Roger Andersen, MD, MPH, RAC[2] , Caetano Sabino, Ph.D[1] , Carolyn Cross, CFA[2], Jason Hickok, RN, MBA[2]

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[2] Ondine Biomedical, Inc., Vancouver BC

Abstract

Antimicrobial Photodisinfection Therapy (aPDT) is a non-invasive, rapid, and effective infection control technology capable of eradicating a wide range of pathogens. Deployed in Canada as well as other countries, a PDT has been clinically proven to significantly reduce surgical site infections with only minimal adverse events. Its broad-spectrum efficacy, economic benefits, and ease of integration into clinical workflows make it a sustainable alternative to antibiotics.

The first accounts of using light for the treatment of physical illness appeared in Egyptian, Indian, and Chinese writing more than 30 centuries ago (1). The first detailed evidence for the antimicrobial activity of certain photosensitizers combined with light was documented in Munich by Oscar Raab (3). Overshadowed by the development of antibiotics, another 80 years would pass before seminal work in antimicrobial photodynamic therapy (aPDT, photodisinfection) began to appear in the literature (4, 5). A large number of presentations are now regularly made on this topic at international conferences and photodynamic therapy in general has become mainstream medicine.

Ondine Biomedical Inc. (Vancouver, B.C.) has pioneered the use of a safe, effective photosensitizer solution (PS) based on the phenothiazinium methylene blue for topical application to human tissues. The primary application for this technology is to eradicate potentially pathogenic microorganisms from the anterior nares prior to surgery, in order to reduce the incidence of surgical site infections (Steriwave™ nasal photodisinfection system). The photosensitizer is applied by swab to the nose, followed by laser light activation via disposable light diffuser for 4 minutes. The non-invasive, painless technique has been shown to eradicate pathogenic microorganisms including Gram-positive and Gram-negative bacteria, viruses, protozoa, and fungi and, unlike traditional antibiotics, does not induce resistance following repeated exposures to the therapy (6-14).

Ondine has commercially deployed aPDT at tertiary care and other facilities in Canada over the past five years, successfully

Benefits of Antimicrobial PhotoDisinfection Therapy (aPDT)

- Non-invasive, Rapid
- Clinically Proven
- Broad-Spectrum Efficacy
- Economic Benefits
- Ease of Integration and Use
- Sustainable Alternative
- High Safety, Low Adverse Events

treating the anterior nares of > 150,000 patients in order to eliminate microbes causing surgical-site infections. Surgical-site infection rates can be reduced by >50% with extremely low adverse events rates (<0.1%) and no serious adverse events whatsoever. The system is Health Canada approved for reduction of potentially pathogenic microorganisms in the anterior nares, and has gained a CE Mark for the same indication.

In addition to superior patient outcomes, aPDT has been shown to demonstrate significant pharmacoeconomic benefit in clinical settings, especially when deployed in lengthy procedures coupled with high propensity for surgical site infection such as spine surgery (16). Recent publications from the CDC (17) and the Council of Canadian Academies (18) detail the growing economic impact resulting from increasing antimicrobial resistance to global economies, confirming the enormously expensive predictions made in the O'Neill Report (19). By contrast, aPDT is highly effective, does not promote antimicrobial resistance and reduces reliance on existing antibiotics, making it an important component of the clinical armamentarium in today's surgery suites.

Specifications

The aPDT system consists of an activating laser light source which is connected to a disposable light diffuser through an umbilical cable:

The light activating device consists of a two-channel red laser diode (664 nm, 150 mW/cm^2, 36 J), robustly designed for presurgical environments. The system intentionally does not include a screen, but rather power/start /stop buttons designed for simplicity and speed. Internal components are not user-serviceable, and include laser diodes, fiber optic cable assemblies, electronic circuit boards, a remote-access use counter and mounting hardware. External surfaces consist of appropriately manufactured and bonded plastic components which may be easily cleaned using standard hospital disinfectants including hydrogen peroxide.

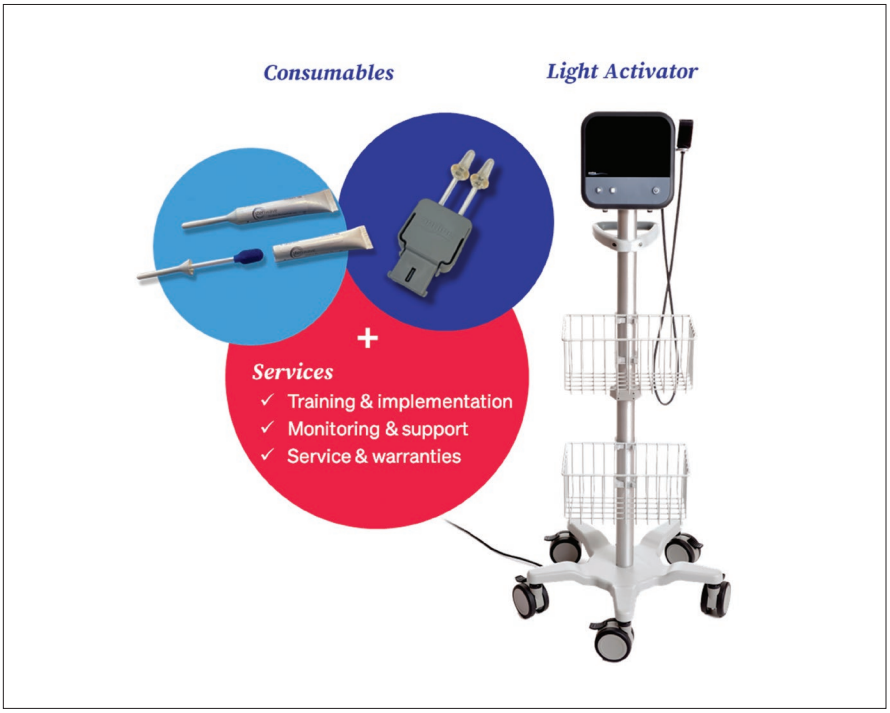

Figure 1: The Steriwave™ nasal photodisinfection system. Source: Ondine Biomedical, Inc.

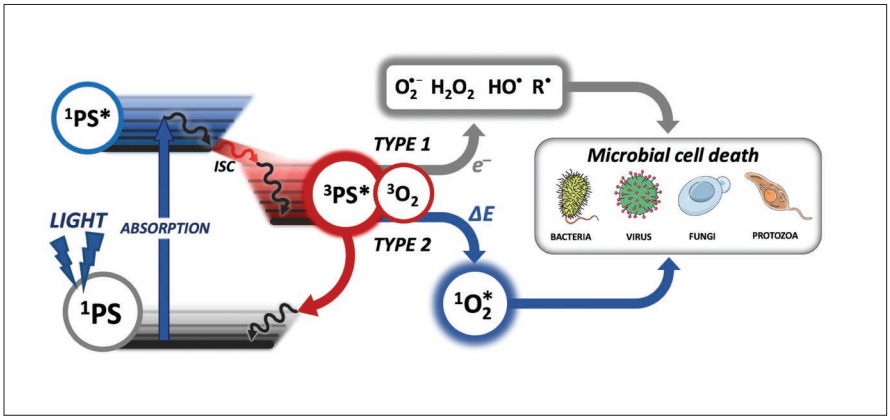

Figure 2: The electrodynamics of photodisinfection therapy. Source: Ondine Biomedical, Inc.

The system is delivered mounted to a five-wheel rolling medical cart which incorporates powder-coated surfaces, cable management and wire-basket consumables storage.

The process of photodynamic activation relies on light being absorbed by a photosensitizer molecule within an absorption spectrum band (Figure 2). Ground-state electrons move to a higher excited state during this absorption/ activation event, followed by production of reactive oxygen species (ROS) through either via Type I or Type II reaction pathways (2). Type I reactions primarily involve the transfer of charges to a substrate, resulting in the formation of radicals (2). Type II reactions entail the transfer of energy from an excited triplet-state PS to ground-state triplet oxygen, in turn leading to the production of singlet oxygen (2). The ROS generated through Type I and Type II reactions are capable of oxidizing various molecules in the cells of microbes, leading to a rapid microbicidal effect (20). Note that the generation of endogenous ROS in neutrophils, monocytes, and eosinophils is one of the primary means by which

the human immune system combats infecting microbes. Methylene blue is the photosensitizer most commonly used for aPDT (79) because it presents low toxicity in the absence of light (21), selectively accumulates on microbial cells due to its cationic charge (22), produces high yields of singlet oxygen when excited with red light (22) and is a highly effective photosensitizer against drug-resistant pathogens classified as global priority microorganisms (23).

The ROS generated in close proximity to bacterial membranes rapidly results in membrane perforation, protein cross-linking, and consequent cell death. It has been demonstrated that singlet oxygen can exert potent cytotoxic effects on microbes without being internalized (24). The singlet oxygen lifetime in biological media is short – less than 0.05 µs – due to quenching by water, and therefore the mean diffusion distance of the molecule is less than 0.02 µm before returning to ground state (25). This short active lifetime localizes the kill to the immediate vicinity of the activated molecule.

The destructive reactions caused by singlet oxygen are relatively selective for the organisms to which the PS adheres. The destructive effect is further amplified by the PDT "bystander" effect (26), a cooperative inactivation process between cells in a given microcolony, most likely mediated by microbicidal photoproducts or the transfer of lysosomal enzymes from nearby cells. Broad-spectrum activity against viruses is rapid and potent; here the active cidal mechanism involves diffusion-limited penetration across the envelope or capsid, followed by covalent cross-linking and destruction of side chains and backbone sites at multiple positions on viral proteins. Progressive downstream chain reactions also cause aggregation, altered conformation and directly oxidized guanosine residues, cross-linking, scission and irreversible oxidation of viral DNA and RNA.

Metrics

The treatment of infections by APDT has been extensively studied for many years and has become a well- established therapeutic option in several clinical presentations including dentistry. Several reviews have demonstrated efficacy in treatment of periodontitis (27, 28, 29), caries (30), endodontic infections (31), and peri-implantitis (32). aPDT has also been found to be effective in the treatment of a variety of other infectious diseases caused by bacteria, fungi and protozoa including brain abscesses (33), acne (34 - 39), folliculitis (40), H. pylori (41), diabetic and skin ulcers (42 - 45), interdigital mycosis (46), keratitis (47), onychomycosis (48), candidiasis (49), cutaneous leishmaniasis (50), oral paracoccidiodomycosis (51), and refractory chronic rhinosinusitis (52).

As a nasal decolonizing modality, the technology was clinically trialed and proven in a major controlled study (53) alongside chlorhexidine body wipes, demonstrating significant efficacy, safety and pharmacoeconomic benefits in patients undergoing elective cardiac, orthopaedic, spinal, vascular, thoracic and neurosurgical procedures. Standard SSI surveillance methodology was used to follow patients for one year after surgery. Results in 3,068 patients were compared with those for a four-year historical control group of 12,387 patients as well as those for a concurrent control group of 206 untreated patients. A significant reduction in the SSI rate was observed between treated patients and the historical control group [1.6% vs 2.7%, P = 0.0004, odds ratio (OR) 1.73, 95% confidence interval (CI) 1.28-2.34]. This significant reduction was maintained on intent-to-treat analysis (P = 0.021, OR 1.37, 95% CI 1.04−1.78). Overall compliance with the therapy was 94%. A 1:4 propensity score analysis of matched treated and untreated patients demonstrated that treatment reduced the risk of SSIs significantly (P = 0.00026, z = 3.65). Conclusion of the study was that the combination of CHG wipes and aPDT immediately before surgery reduced SSIs, achieved excellent compliance, and was easily integrated into the pre-operative routine. Since this study, over 150,000 patients have undergone treatment to reduce SSI rates, reduce antibiotic use, reduce length of stay, reduce readmission and return to ER rates, reduce reoperation rates and reduce unnecessary cost associated with SSI morbidity.

Treatment of viral infections with aPDT also has a long clinical history. Methylene-blue mediated photodisinfection has been used for decades to inactivate viral (and other) pathogens in blood products in Europe (Theraflex®, Macopharma, Lille, France). As early as 2011, our group investigated the possibility of inhibiting mother-to-child transmission of HIV using a phage surrogate, and found that we could inactivate 100% of the virions as expected (54). In the 1970s, a series of clinical studies demonstrated efficacy in treating infections due to the herpes simplex virus (55, 56). The most widely investigated viral infections have been those associated with human papilloma virus (HPV), a group of more than 150 types of viruses that affect the skin and mucous membranes. In addition to causing diseases such as respiratory papillomatosis, genital warts, and skin warts (57), certain HPV types are carcinogenic and can result in cervical, vulvar, penile, and anal intraepithelial neoplasia (58, 59). aPDT using a variety of photosensitizers has been shown to be successful in the treatment of a range of HPV-associated infections including respiratory papillomatosis (60, 61), plantar warts (62), condylomata acuminate (63), cervical intraepithelial neoplasia (64, 65), and penile intraepithelial neoplasia (66).

The ongoing transmission and geographic expansion of SARS-CoV-2 in human populations spurred Ondine to develop aPDT as an antiviral application targeting the anterior nares staging site, as well as the tracheobronchial ecological niche of this virus within the human host. In the last 20 years, three coronaviruses have crossed the species barrier causing disease in humans - SARS-CoV in 2002, MERS-CoV in 2012 and SARS-CoV-2 in 2019. HCoV case fatality ratios range from 0.5−20% with disproportionate impact on immunocompromised and elderly populations. Infection is known to occur from the luminal side of the airway, and progeny viruses are released from the same side facilitating spread through coughing and sneezing. This provides

	Current options are failing			Better intervention
	Current standard of care  Mupirocin	 Povidone iodine	 Alcohol	 Steriwave
# of applications needed (for pre-surgical use; 48hrs to primary wound closure)	**10** *Twice daily for 5 days prior to surgery*	**4-5** *Every 12 hours, pre-surgery → 48hrs post*	**4-5** *Every 12 hours, pre-surgery → 48hrs post*	**1** *Single treatment pre-surgery*
Effective against bacteria?	✓	✓	✓	✓
Effective against viruses?		✓	✓	✓
Effective against fungi?		✓	✓	✓
No resistance?			✓	✓
Immediate efficacy?				✓
High compliance rates?				✓
Easy workflow?				✓
	Resistance as high as 81% has been reported			

Figure 3: Conventional nasal decolonization approaches contrasted to aPDT.

a useful target for aPDT. While mRNA construct vaccines are effective, viral infection often progresses to the point of symptom development before the humoral immune response predominates. By contrast, prompt and early aPDT treatment directly in the anterior nares has been demonstrated to reduce the course and severity of COVID-19 (67, 68, 69), making aPDT a potentially ideal adjunct to mRNA vaccines.

Practice changes

First-line approaches to nasal decolonization often employ modalities that must be reapplied, do not target a broad spectrum of microbes, or cause resistance in the targeted pathogen (Figure 3).

Importantly, the workflow impact of aPDT is minimal, especially when contrasted to the standard of care antibiotic mupirocin. The antibiotic is bacteriostatic, and must be applied twice a day for five days, resulting in poor patient compliance and a porous infection control regimen. aPDT is bactericidal, and may be applied at any time including as the patient is being wheeled into surgery, a critical advantage for emergency cases or those without time for five-day prophylaxis. (53) demonstrated overall compliance with the rapid aPDT nasal decolonization regimen at 94%.

The damage inflicted by pathogenic microbes on their host, as well as their ability to avoid host defense systems, is mediated by a variety of virulence factors such as exotoxins, endotoxins, capsules, adhesins, invasins, and proteases (70). While antibiotics can kill microbes and thereby prevent further production of host-damaging virulence factors, few have any effect on pre-existing virulence factors or those which are released during the cidal process. These factors can continue to produce damaging effects even after the offending microbes have been killed (71). In contrast to most antibiotics, light-activated PS's are generally able to neutralize microbial virulence factors or reduce their effectiveness or decrease their expression. The ability to modify the biological activities of lipopolysaccharides (LPS, endotoxin) is of particular interest because LPS's are potent immunomodulators that can induce secretion of several proinflammatory cytokines by host cells (72-77). Activated photosensitizers have been shown to be potently effective at reducing the activity of LPS, proteases, and a variety of exotoxins. The bimodal ability to eliminate microbes responsible for an infection and to simultaneously inactivate or decrease the expression of many of the molecules responsible for host tissue destruction constitutes an important advantage over most antibiotics, as this combines both antimicrobial and anti-inflammatory approaches into a single treatment. Recent work in SARS-CoV-2 further demonstrates that aPDT is capable of producing a humoral (vaccine-like) immune response despite the topical nature of the treatment (67).

Because the aPDT approach does not enhance resistance, treatments may be repeated without concern at the facility level. MRSA killing and re-culturing experiments carried out over several consecutive years demonstrated no decrease in susceptibility to aPDT, whereas high-level resistance to oxacillin was established after less than a dozen cycles (6). This finding has been duplicated in studies with more complex sensitizers (7) and also in viruses, where no increase in resistance was demonstrated after numerous cycles of aPDT (8). Numerous studies have duplicated this finding (9-15). In particular, the speed of kill and the external peroxidative mechanism of ROS appear to limit the ability to develop resistance to aPDT (78) in part because the genome is not substantially exposed to the cidal mechanism.

Implementation

The aPDT system is conveniently wheeled to the patient's bedside and set up by

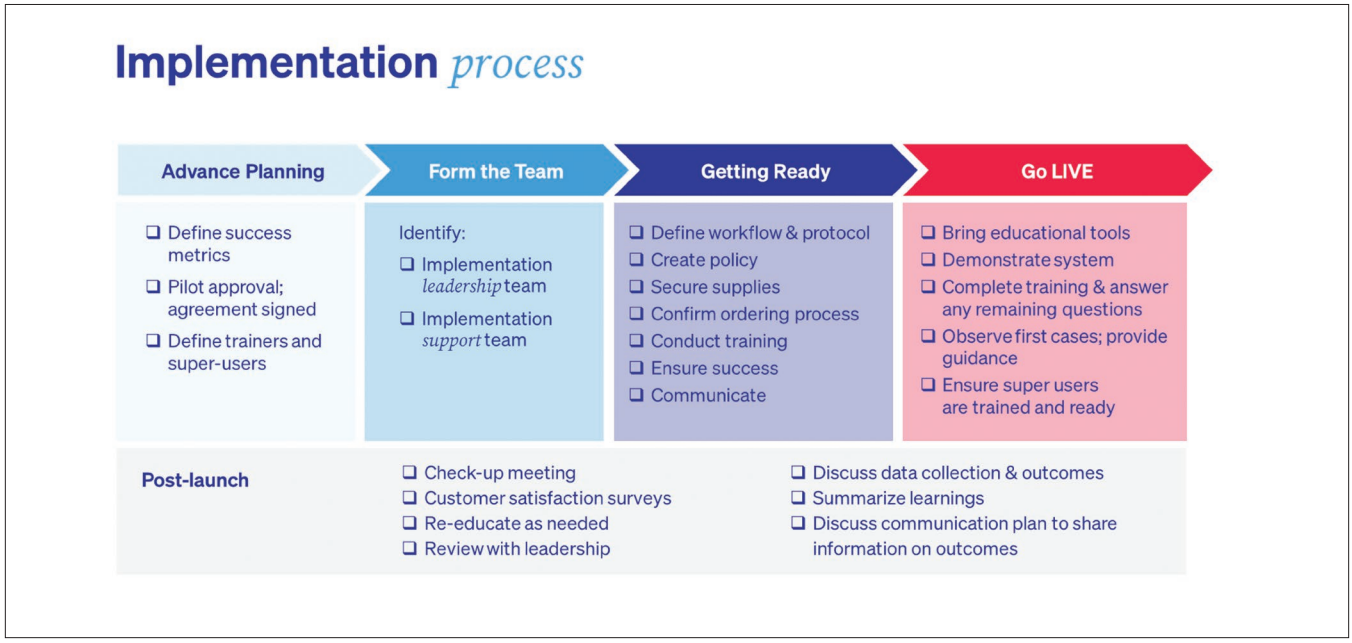

Figure 4: Full Steriwave implementation process and post-launch follow-up designed to assure success.

preoperative nursing staff before surgery. Its design ensures compatibility with current delivery practices and easy patient access. The treatment is painless, requiring only light-blocking glasses to enhance patient comfort. Patients can be treated while seated or lying down and may be awake or sedated.

Typically, the treatment begins in the presurgical holding area about two hours before surgery. The photosensitizer is gently swabbed into the patient's nostrils using presaturated foam swabs from a sealed container. A disposable light diffuser is then attached to the umbilical cable, and the diffuser tips placed into the nostrils. The system is activated to emit light for two minutes, followed by a repeat of the swabbing and illumination for another two minutes to complete the therapy. The treatment can be administered by nursing staff or by the patient holding the device themselves. After use, all consumables are disposed of in medical waste.

The only routine maintenance required involves a hard-surface wipe down of the device. Additionally, once a quarter, or as per hospital protocol, the system's laser power is checked by the hospital's Biomedical Engineering and Technology (BMET) team. This check is performed by connecting the umbilical connector block to a specially designed power meter that safely bypasses the laser interlocks and verifies the correct optical power levels. The meter then provides a simple go/no-go indicator. The laser illuminator is highly reliable, requiring minimal maintenance throughout its designed operational life of five years, even under high-use conditions.

Ondine Biomedical is dedicated to providing comprehensive support for the entire lifecycle of the system, from initial implementation and training to ongoing monitoring, support, and any necessary service and warranty needs as illustrated in Figure 4.

The system may be deployed by any healthcare practitioner, and benefits from designed-in simplicity and speed. Patients often comment on the high-tech nature of the system, and this extends to the experience of the practitioner lighting up patient's noses with bright red light. During the end of year holiday period when intake units are short-handed and especially busy, clinicians report having to endure Rudolph jokes. The speed, low-cost, and high efficiency of the system more than makes up for this.

Clinical Benefits

- Reduction in SSIs
  - o Preoperative nasal decolonization
  - o Evidence-based approach
- Decreased Transmission in Healthcare Settings
  - o Lowered carrier rates
  - o Protection for immuncompromised patients
- Enhanced Antibiotic Stewardship
  - o Reduction in antibiotic usage
- Cost-Effectiveness
  - o Economic benefits – decreased length of stay, reduced infection management costs
- Ease of Use and Safety
  - o Simple application
- Adaptation to Pandemic Protocols
  - o Respiratory Infections Controls – additional measure to reduce viral load

Narrative

Integration of the Steriwave aPDT system into the presurgical units at Vancouver General Hospital represented a significant advancement in combating SSI's. This innovation shifted the paradigm from dependency on patient adherence to complex twice-daily antibiotic regimens to employing a straightforward, modern, pre-surgical decolonization technique. This method not only simplifies the process but also ensures consistent application of best practices in SSI prevention across the healthcare continuum—from the hospital's financial decision-makers to the surgical teams, including preoperative nurses and surgeons. Nurses are now actively involved in infection control, which enhances patient safety and minimizes risk. The system's flexibility permits decolonization of emergency surgery cases ranging from trauma cases to oncology and emergency room admissions, none of which were previously covered by antibiotic prophylaxis.

Comprehensive data collected from tens of thousands of patients validate the system's effectiveness, showing a reduction in SSI rates by over 50%. Pharmacoeconomic analysis confirms a substantial return on investment, with savings in the $millions due to fewer infections, reduced readmission rates, and more efficient use of hospital beds. The ease of use of aPDT and high compliance rates when administered by nurses have been crucial to its widespread acceptance. As one orthopedic patient poignantly noted in 2018, "I came here to get my new shoulder because my sister was here for hers, and she didn't get an infection. I want that red light!"

Ondine Biomedical Inc., headquartered in Vancouver, B.C., with R&D facilities in Bothell, Washington, USA (www.ondinebio.com, info@ondinebio.com, 604-669-0555), was founded in 1997. Ondine is committed to developing non-antibiotic therapies for treating a wide range of microbial infections using anti-infective photodisinfection. Steriwave™, Ondine's flagship product, offers a revolutionary photonic approach to nasal decolonization, effectively eradicating pathogens in minutes without damaging human tissue or promoting antibiotic resistance. Recognized as a global leader in aPDT technology, Ondine has received numerous accolades and awards for its contributions to enhancing patient safety and surgical outcomes. In addition to nasal decolonization, Ondine is pioneering technologies to combat hospital-acquired infections, including the disinfection of endotracheal tubes to prevent ventilator-associated pneumonia (VAP) and the sterilization of catheter hubs to curtail catheter-associated infections (CAIs). The company is also developing advanced solutions like balloon-catheter therapies for chronic infections such as Chronic Refractory Sinusitis (CRS), and is exploring next-generation products including pulmonary antiviral treatments, mobile photodynamic wound dressings, and pre-graft photodynamic treatments for burn wounds.

In conclusion, Antimicrobial Photodisinfection Therapy stands as a pivotal innovation in infection control, offering a non-invasive, rapid, and effective solution to eradicate a wide range of pathogenic microorganisms. Its successful clinical deployment in Canada, marked by a significant reduction in surgical site infections and low adverse event rate, underscores its potential as a mainstream medical treatment. The broad-spectrum efficacy, demonstrated pharmacoeconomic benefits and ease of integration into clinical workflows position aPDT as a sustainable and superior alternative to traditional antibiotics. aPDT promises to play a crucial role in addressing the global challenge of antimicrobial resistance, enhancing patient safety, and improving clinical outcomes worldwide.

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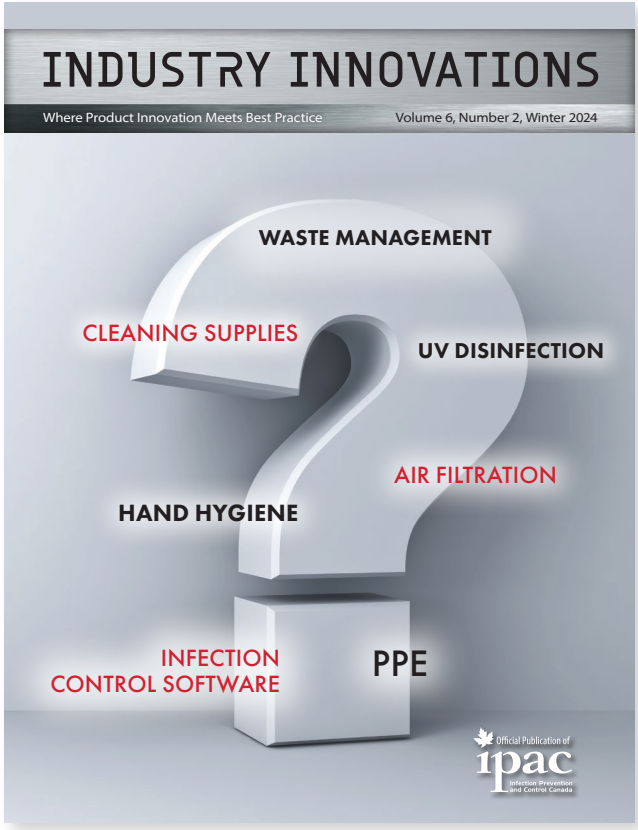

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PROCESS CLEANING SOLUTIONS

Une approche scientifique à l'art du nettoyage ®

PCS Buffered pH Bleach: The Better Bleach

Abstract

The healthcare industry faces an urgent need for advanced disinfecting technologies which are both safe and effective for environmental decontamination against a wide range of pathogens. These technologies should address clinically relevant bacteria, viruses, fungi, and *Clostridioides difficile* spores.

Traditional solutions, such as alkali bleach formulations and hydrogen peroxide disinfectants, have notable limitations. While alkali bleach is effective, it requires high concentrations of sodium hypochlorite (5,500 to 14,000 ppm) and an alkaline pH (11 to 12.5), which, according to the warning label on wipes with a .55% bleach disinfectant, may cause irritation resulting in strong odours, and may lead to potential health risks with repeated use. Conversely, hydrogen peroxide disinfectants, despite their growing acceptance, lack sporicidal efficacy unless used at extremely high concentrations (above 40,000 ppm), which may release harmful vapours.

"We speculate that H_2O_2 levels near the application surface (floor) might be much higher. This could imply that although H_2O_2-based cleaning products are likely safe during household cleaning, people who apply the cleaning agent could possibly be exposed to episodic exceedances of safe H_2O_2 levels during the application of the cleaner. Exposure may be lower when ACR is higher (for example, when windows are opened). The potential health hazard

of H_2O_2-based cleaner, especially for people such as janitorial or housekeeping staff who use these products regularly, warrants further investigation." (Zhou et al., 2020, p. 15643).

BIOFILMS

The challenge of biofilms on surfaces further complicates the disinfection process. Hypochlorites, the most widely used of the chlorine disinfectants, are available in liquid form, e.g., sodium hypochlorite, or in solid form, e.g., calcium hypochlorite. The most prevalent chlorine products in the United States are aqueous solutions of 5.25%-6.15% sodium hypochlorite (see glossary), usually called household bleach. They have a broad spectrum of antimicrobial activity, do not leave toxic residues, are unaffected by water hardness, are inexpensive and fast acting, remove dried or fixed organisms and biofilms from surfaces, and have a low incidence of serious toxicity. (Centers for Disease Control and Prevention [CDC], 2023).

Quaternary disinfectants deposit residues that linger on indoor surfaces and in our sanitary waste stream. They react with other pollutants, contributing to the mixed pollutants that cause increases in the development of antibiotic-resistant bacteria (World Health Organization [WHO], 2023).

Results

Biofilms are frequently present on hospital environmental surfaces and reusable medical equipment (Weber, Rutala, Anderson, & Sickbert-Bennett, 2023). Important healthcare-associated pathogens that readily form biofilms on environmental surfaces include Staphylococcus aureus, *Pseudomonas aeruginosa,* and *Candida auris*. Evidence has demonstrated that biofilms interfere with cleaning and disinfection.

Urgent global threat

Antimicrobial resistance is an urgent global public health threat, killing at least 1.27 million people worldwide and associated with nearly 5 million deaths in 2019. Future research is urgently needed to develop methods to reduce or eliminate biofilms from forming on implantable medical devices, reusable medical equipment, and hospital surfaces. Quaternary disinfectant cleaners, while effective against some pathogens, pose environmental risks by contributing to the development of antibiotic-resistant pathogens when released into sanitary sewers. The *Environmental Science & Technology Journal* highlights the need to address antimicrobial resistance and recommends limiting non-essential uses of antimicrobial quaternary ammonium compounds (QACs)."

"Environmental Science & Technology 2023 57 (20), 7645-7665 DOI: 10.1021/acs.est.2c08244 Quaternary Ammonium Compounds: A Chemical Class of Emerging Concern

Policy Recommendations

Immediate action to address the known threat of antimicrobial resistance is required. The CDC recommends prescribing antibiotics only when necessary, and educating the public about their proper use. Similar efforts to eliminate non-essential uses of antimicrobial QACs in consumer products are warranted.

For example, product labelling requirements could state: "To reduce the public health threat of antimicrobial resistance, use this product only when disinfection is necessary and not for general cleaning."

Manufacturers should also be discouraged from implying a health benefit of QAC use in coatings or durable product treatments without supporting evidence that these treatments are effective in reducing the transmission of infectious diseases.

Quaternary Ammonium Compounds (QACs), Phenols and Biguanides

Note: QACs are not a commonly used disinfectant in Scottish health and care settings as they have limited sporicidal efficacy and minimal activity against non-enveloped viruses. (ARHAI Scotland, 2022)

In response to these challenges, we have developed PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner. This innovative solution offers a low-odour formulation with a buffered pH of 8.5 and a 50% reduction in sodium hypochlorite concentration (0.26%), aligning with modern healthcare requirements. It has rapid disinfection capabilities, killing *Clostridioides difficile* spores in five minutes, while offering broad-spectrum efficacy against bacteria, viruses, and fungi. This mild yet effective formulation is suitable for use across various settings, (Buffered pH and lower concentration of sodium hypochlorite makes the product safer to use and handle and less damaging to surfaces) including acute care, long-term care, food processing, public health facilities, homes, institutions, schools, animal housing, and the hospitality industry.

Available in convenient wipe kits and adaptable to various application methods (such as spray-wipe techniques and squirt tops), PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner ensures safe and effective protection of public health by eliminating organic soils that pose health risks. PCS provides comprehensive support for procurement, staff training, and implementation, facilitating a smooth transition to this new product with minimal disruption.

By adopting PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner, healthcare facilities can support Canadian innovation, create jobs, and enhance public health safety.

PCS Buffered pH Bleach: The Safer, More Effective Disinfectant

- **Surface and staff safe:** With a pH of 8.5 and 50% less sodium hypochlorite, it maintains disinfecting power while being safer for surfaces, staff, and occupants. Kills *Clostridioides difficile* spores.
- **Versatile application:** Suitable for various application techniques, making it perfect for protecting public health through oxidizing cleaning and disinfecting.
- **Wide range of uses:** Ideal for hard, non-porous surfaces in homes, food-processing areas, hospitals, healthcare facilities, institutions, schools, animal housing, and hospitality industries.

- **Critical care decontamination:** Perfect for professional decontamination of food contact surfaces, washrooms, and animal husbandry, including veterinary clinics, and public settings at risk of pathogen transmission.
- **Biofilm penetration:** More effective than alkali bleach at penetrating and dissolving biofilm matrices, making it ideal for healthcare environments.
- **Prevent and eliminate biofilms:** Regular use prevents and removes biofilms. Ideal for deep cleaning to end pathogen outbreaks and reduce pathogen transfer in healthcare settings.
- **Proudly Canadian:** Designed and manufactured with advanced Canadian technology.

Choose PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner for a safer, more efficient way to maintain a clean and healthy environment.

Product Code

- #6283-6 6 x 946 mL per carton
- #6283-4 4 x 3.78 L carton
- #6285-2 PCS Buffered pH Bleach Wipe Application Kit (contains 2 x 946 ml PCS Buffered pH Bleach
- Only two rolls of 80 wipes 25x30.48 cm and two dispensing buckets)
- Keep out of reach of children. Caution. May irritate eyes.

Bacteria,Virus, Fungus and *Clostridioides difficile* Spores	Contact time
Staphylococcus aureus (ATCC 6538)	1 minute
Pseudomonas aeruginosa (ATCC 15442)	1 minute
Feline Calicivirus (as surrogate for Norovirus	1 minute
Adenovirus Type 5 (ATCC #VR 1516)	1 minute
Trichophyton interdigital (ATCC #9533)	1 minute
Clostridioides difficile spores (ATCC #43598)	5 minutes

PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner for use on hard non-porous environmental surfaces in domestic settings, food processing areas, hospitals, healthcare facilities, institutions, schools, animal housing areas and hospitality industries.

To clean and oxidize frequently touched surfaces, apply undiluted solution to the surface. Wipe dry with a microfibre or other clean, dry absorbent cloth, rinse, or allow to air dry.

To pre-clean prior to, add 30 mL to 1 litre of water in a bucket or workplace spray bottle and spray the surface until wet, or wipe with a moistened cloth. Wipe dry with a microfibre or other clean, dry absorbent cloth, rinse, or allow to air dry. To disinfect frequently touched surfaces such as non-critical medical equipment, bed rails, washroom fixtures, and surfaces that are potential fomites in healthcare facilities, long-term care, schools, and institutions, spray or apply the solution to pre-cleaned surfaces. Allow the surface to remain wet for the indicated time below. Wipe the surface dry, rinse, or allow it to air dry.

Bacteria/Virus	Contact time
Staphylococcus aureus (ATCC 6538)	1 minute
Pseudomonas aeruginosa (ATCC 15442)	1 minute
Feline Calicivirus (as surrogate for Norovirus	1 minute
Adenovirus Type 5 (ATCC #VR 1516)	1 minute
Trichophyton interdigital (ATCC #9533)	1 minute
Clostridioides difficile spores (ATCC #43598)	5 minutes

This product is a broad-spectrum virucidal hard surface disinfectant that is expected to inactivate the SARS-CoV-2 (the virus that causes COVID-19)

- Kills 99.99% of bacteria and viruses
- Kills *Staphylococcus aureus*, *Pseudomonas aeruginosa*
- Broad Spectrum Virucide kills Adenovirus Type 5, Feline Calicivirus (as surrogate for Norovirus)
- Bactericide/Virucide
- Kills Trichophyton interdigitale fungus
- Kills spores of *Clostridioides difficile*

PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner

Nettoyant désinfectant oxydant à l'eau de Javel tamponnée pH PCS.

- Oxidizing cleaner
- Oxidizing hospital-grade disinfectant
- Oxidizing broad-spectrum virucide and fungicide
- Kills spores of *Clostridioides difficile*
- Active Ingredient sodium hypochlorite 0.26 %w/w when packed

CAUTION: READ THE LABEL BEFORE USING
KEEP OUT OF REACH OF CHILDREN

- Nettoyant oxydant
- Désinfectant de grade hospitalier oxydant
- Virucide et fongicide à large spectre oxydant
- Élimine les spores de
- *Clostridioides difficile*
- Ingrédient actif Hypochlorite de sodium 0,26 % p/p lors de l'emballage

DIN: 02548534

CAUTION: IRRITANT LIRE L'ÉTIQUETTE AVANT L'EMPLOI GARDER HORS DE LA PORTÉE DES ENFANTS ATTENTION : IRRITANT

946mL

Directions for use to kill *Clostridioides difficile* spores: This product kills and/or inactivates spores of *Clostridioides difficile* (ATCC 43598) on hard, non-porous surfaces after a five-minute exposure time.

Directions for cleaning prior to disinfection against *Clostridioides difficile* spores:
Personal protection: Wear appropriate barrier protection, such as gloves, gowns, masks, and eye covering.

Cleaning procedure: Fecal matter and waste must be thoroughly cleaned from surfaces and objects before disinfection by applying a microfibre or other absorbent cloth, mop, or sponge saturated with a solution of 30 mL per litre of water. Cleaning should include vigorous wiping and scrubbing until all visible soil is removed. Special attention is needed for high-touch surfaces. Surfaces should be cleaned in an appropriate manner, such as from right to left or left to right on horizontal surfaces, and from top to bottom on vertical surfaces to minimize the spread of spores. Restrooms should be cleaned last. Do not reuse soiled cloths.

Infectious material disposal: Materials used in the cleaning process that may contain feces/waste should be disposed of immediately in accordance with municipal, provincial, or territorial infectious materials disposal requirements.

To disinfect against *Clostridioides difficile* spores, apply the solution with a mop, microfibre cloth, other absorbent cloth, sponge, brush, disposable wipe, or by soaking, ensuring all surfaces are thoroughly wet. If applying with a spray device, hold the bottle upright 15–20 cm from the surface. Always close the nozzle after use. Allow surfaces to remain wet for a minimum of five minutes, then either allow to air dry or, if desired, wipe dry with a microfibre cloth or another clean, dry absorbent cloth, or rinse. Rinse with potable water any surfaces that come in contact with food and any surfaces or objects that come in contact with children at the mouthing stage of development.

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EDITOR'S NOTE: While this white paper provides timely information on an important topic, readers are advised that the data, references and findings within this paper have not been fully verified nor endorsed by Industry Innovations.

Next Generation Protection Against Biofilm Pathogens

New cleaning strategies involving safer, more dilute forms of stabilized PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner DIN:02548534 Contains 0.26% Sodium Hypochlorite. Hospital Grade Disinfectant,Broad Spectrum Virucide and Fungicide Kills Clostridiodes difficile spores .

Use PCS Apply and Dry Surface Cleaning

Validated cleaning process to remove C.difficile spores and prevent pathogen transfer. Quantitative Carrier Test #3

PCS Apply and Dry Health Care Enhanced Daily and Discharge Oxidizing Disinfectant Cleaning.

To Clean and Oxidize apply to surface with dampened wiper wait 1 minute and wipe dry with PCS Hygienic microfiber cloth.

To kill and remove Bacteria,Viruses, Fungi C. difficile spores, biofilm matrix residues and prevent pathogen transfer.

No need to use disinfectants that are more concentrated and contain Synthetic detergent chemicals that deposit residues in the environment that contribute to the creation of antibiotic resistant pathogens.

Ingredients

Chemical Name CAS#
Water 7732-18-5
Sodium Hypochlorite 7681-52-9
Acetic Acid 64-19-17
Sodium Hydroxide 1310-73-2
Sodium Bicarbonate 144-19-8
Sodium Carbonate 497-19-8
Sodium Chloride 7647-14-5

Bacteria,Virus, Fungus and C. Diff Spores	Contact time
Staphylococcus aureus (ATCC 6538)	1 minute
Pseudomonas aeruginosa (ATCC 15442)	1 minute
Feline Calicivirus (as surrogate for Norovirus)	1 minute
Adenovirus Type 5 (ATCC #VR 1516)	1 minute
Trichophyton interdigitale (ATCC #9533)	1 minute
Clostridioides difficile Spores (ATCC #43598)	5 minutes

We offer the potential of combating biofilms that form on dry hospital surfaces and equipment. With PCS Apply and Dry cleaning method,the bulk of the biofilm pathogenic bacteria problem is solved by physical removal of the biofilm matrix during efficient cleaning.

Biofilms on frequently touched surfaces and equipment interfere with surface cleaning and disinfection. PCS Buffered pH Bleach Oxidizing Disinfectant Cleaner concentration and neutral pH penetrates through biofilm matrix making it possible to wipe surface clean with our microfiber cloth.

PCS products contain only inorganic and organic ingredients, free of any perfumes ,petrolium based ingredients that add to the contaminants in waste water treatment plants.

European Union Risk Assessment Report SODIUM HYPOCHLORITE
"Summary of environmental degradation of sodium hypochlorite. In water, in the sewer and during sewage treatment, the degradation of hypochlorite is modeled by Vandepitte and Schowanek and the concentration is calculated to drop down to "zero" within a few minutes after release into the sewer."

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Reducing the development of antibiotic resistant bacterial populations is no longer just an issue for hospitals. We all need to do what we can, because the same conditions that promote resistance operate not only in hospitals but in other environments as well.

Microbiology 2023
Biological and synthetic surfactant exposure increases antimicrobial gene occurrence in a freshwater mixed microbial biofilm environment

Int. J. Environ. Res. Public Health 2023,
Organic Compounds and Antibiotic-Resistant Bacteria Behavior in Greywater Treated by a Constructed Wetland

Heliyon (2023)
Direct Environmental concentrations of surfactants as a trigger for climax of horizonal gene transfer of antibiotic resistance

Water Research Volume 236, 1 June 2023, 119944
Direct The structure of biodegradable surfactants shaped the microbial community, antimicrobial resistance, and potential for horizontal gene transfer

Environmental Science & Technology 2023 57 (20), 7645-7665 DOI: 10.1021/acs.est.2c08244
Quaternary Ammonium Compounds: A Chemical Class of Emerging Concern
Policy Recommendations - Immediately address the known threat of antimicrobial resistance. The medical field recommends that antibiotics be prescribed only when necessary and educate the public about proper use. Similar efforts to eliminate non-essential uses of antimicrobial QACs in consumer products are warranted. An example would be product labeling requirements such as

“To reduce the public health threat of antimicrobial resistance, use this product only when disinfection is necessary and not for general cleaning”.

Manufacturers should also be discouraged from implying a health benefit of QAC use in coatings durable product treatments without supporting evidence that these treatments are effective in reducing the transmission of infectious diseases.

2023 United Nations Environment Programme
The environmental dimensions of AMR include pollution from hospital and community wastewater, effluent from pharmaceutical production, run-off originating from plant and animal agriculture and other forms of waste and releases. These matrices may contain not only resistant microorganisms, but also antimicrobials, various pharmaceuticals, microplastics, metals and other chemicals, which all increase the risk of AMR in the environment. Polluted waterways, particularly those that have been polluted for some time, are likely to harbour microorganisms that increase AMR development and distribution in the environment. With increasing pollution and lack of management of sources of pollution, combined with AMR in clinical and hospital settings and agriculture, risks are increasing.

HYGIENIC ECHO INC.

The Buddy Badge System™ by Hygienic Echo Inc. Helping Each Other Save Lives™

Abstract

The Buddy Badge System™ by Hygienic Echo is a ground-breaking hand hygiene performance tool designed to prevent hospital infections by leveraging advanced artificial intelligence (AI) and sensing technologies. Effective hand hygiene significantly reduces the risk of surgical site infections, thereby enhancing overall patient safety in the preoperative room, the operation room, and the Intensive Care Unit (ICU)[1–3]. This paper presents an overview of the Buddy Badge System™, emphasizing its innovative approach to infection prevention in surgical settings.

One of the core strengths of the Buddy Badge System is its ability to provide individual performance measures. By monitoring each caregiver's hand hygiene actions, the system offers real-time feedback to help achieve compliance with established protocols. This immediate feedback loop is crucial in high-stakes environments like surgical units, where patient safety is of primary concern, and the risk of infection must be minimized. The system's use of gamification further enhances compliance, as it incentivizes proper hygiene practices through positive reinforcement and rewards [4,5]. This approach not only improves individual performance but also fosters a culture of accountability and continuous improvement within the healthcare facility [5].

Integration with existing workflows is another significant advantage of the Buddy Badge System. Healthcare workers often face high-pressure situations, and adding new tasks or procedures can be challenging. The Buddy Badge System is designed to integrate seamlessly into the daily routines of caregivers without adding additional burdens. Its intuitive design and ease of use mean that the system can quickly adapt to staff's natural workflow, ensuring that hand hygiene protocols are followed consistently. The system's compatibility with various healthcare environments, including surgical units, makes it a versatile tool for infection prevention.

Ongoing AI-driven research is a key component of Hygienic Echo's strategy to maintain the Buddy Badge System's cutting-edge status. By continually analyzing data collected from the system, Hygienic Echo can identify patterns and areas for improvement, leading to the development of new features and enhancements. This commitment to innovation ensures that the Buddy Badge System remains at the forefront of hand hygiene technology. Current research includes sensing caregiving activities and assigning specific risks that introduce resolutions beyond the 5 moments. Additionally, AI is being employed to provide insights and performance analytics to enable healthcare facilities to maintain high hygiene standards consistently. By fostering a culture of continuous improvement and accountability, the Buddy Badge System stands out as a vital tool in enhancing patient safety and reducing healthcare-associated infections.

Specifications

The Buddy Badge System comprises four primary components. These components are the kiosk/charging station, buddy badges, zone markers, and dispenser counters. Figure 1 illustrates these components and their interactions.

1. **Kiosk/charging station:** Usually placed on each nursing unit near to the nursing station, the kiosk serves two purposes. First, it stores Buddy Badges on magnetic connectors through which data is exchanged and the badges are recharged. Each user is given a personal QR code printed on a roll of stickers. The printed QR code can typically be attached to their ID badge or phone. When the QR code is held in front of the kiosk's scanner, one of the badges starts to flash, indicating that the badge is ready for the user to pick up and clip it over their chest.

Figure 1

2. **Buddy Badges:** These lightweight badges handle all the intelligent processing. They monitor hand hygiene actions and provide real-time feedback to the user. When hand hygiene is performed, the badge glows green for 60 to 80 seconds, allowing entry or exit from patient environments without additional prompts. If hand hygiene is not performed before entry or exit, the badge vibrates gently, reminding the user to clean their hands within 20 seconds. Failure to do so records a missed opportunity, which can be reviewed later through the system's analytics.
3. **Zone markers:** Resembling smoke detectors, zone markers are installed on ceilings. They activate when a person approaches, transmitting an invisible light signal to Buddy Badges. This signal informs the badges of their location and the applicable hygiene rules. Zone markers also transmit maintenance information, such as battery levels, to ensure they remain operational.
4. **Dispenser counters:** Installed alongside every sanitizer and soap dispenser, these counters signal the Buddy Badge whenever a dispenser is used, giving credit to the staff for performing hand hygiene. This integration ensures that hand hygiene actions are accurately recorded and prompts are given as needed.

The installation of the Buddy Badge System is straightforward and non-disruptive. Since the zone markers and dispenser counters are battery-powered and require no computer connections, they can be attached with self-tapping screws. There are no concerns about interference with hospital IT systems or biomedical equipment, as no WIFI, Bluetooth, or other radio-frequency signals are used for communications between Buddy Badges and other system components. All communications are optical except that the kiosk uploads the badge data to the cloud using its own independent Wi-Fi connection.

The use of the Buddy Badge is intuitive and requires only a 5-minute demonstration, Healthcare workers follow their usual practice of performing hand hygiene before entering or exiting a patient's environment. The system's design ensures that hand hygiene protocols are adhered to without adding additional tasks to the caregiver's routine. At the end of each shift, the badges are returned to the kiosk for automatic data upload and recharging, ready for the next use.

The periodic replacement of batteries, managed by hospital maintenance staff or Hygienic Echo's team, ensures continuous operation of the system without frequent interventions. This low-maintenance design makes the Buddy Badge System an efficient and reliable tool.

By integrating seamlessly with existing workflows and providing real-time feedback and data-driven insights, the Buddy Badge System enhances hand hygiene practices, thereby reducing the risk of surgical site infections. Its innovative use of AI and sensing technologies sets it apart as a leading solution in infection prevention, making it an invaluable addition to healthcare teams committed to maintaining the highest standards of patient safety.

Metrics

The Buddy Badge System provides robust tracking capabilities, offering valuable metrics to monitor hand hygiene compliance and its impact on infection rates. These metrics are crucial for healthcare administrators to understand compliance patterns, identify areas for improvement, and implement targeted interventions to enhance overall hygiene practices.

1. **Hand hygiene compliance rate:** The system keeps track of individual compliance rates, providing detailed reports on hand hygiene actions performed by each caregiver. This data is crucial for identifying high-performing individuals and those who may need additional training or support. The ability to track individual performance ensures that all staff members are accountable for maintaining high hygiene standards.
2. **Missed opportunities:** The system records instances where hand hygiene protocols are not followed, referred to as missed opportunities. By analyzing this data, healthcare teams can identify specific areas or times when compliance drops, allowing for targeted interventions to address these gaps. Reducing missed opportunities directly correlates with a decrease in infection risk.
3. **Real-time feedback and alerts:** One of the unique features of the Buddy Badge System is its ability to provide real-time feedback and alerts. When a caregiver fails to perform hand hygiene, the system immediately prompts them with a vibration and a visual cue. This immediate feedback loop helps instill better hygiene habits and ensures compliance in critical moments.
4. **Performance trends:** The system's analytics platform provides insights into performance trends over time. Individual users can go to an app on their phone or computer to see a dashboard showing their performance over the last week and comparing that performance to the aggregate group compliance of their nursing unit. An extensive library is available to authorized users in the cloud. Reports are instantly available covering individual users, groups of users, locations and date ranges. Various options for these reports are presented with simple tick boxes. By examining trends, healthcare administrators can assess the effectiveness of hand hygiene initiatives and make data-driven decisions to enhance protocols. For instance, if a particular shift or unit consistently shows lower compliance, targeted training sessions or additional resources can be deployed.
5. **Gamification and positive reinforcement:** The Buddy Badge System incorporates gamification elements to encourage high compliance. Caregivers automatically receive rewards, such as gift cards, for maintaining high hygiene standards. This positive reinforcement has been shown to significantly boost compliance rates, creating a culture of excellence and accountability within the healthcare facility.
6. **Reduction in infection rates:** By maintaining high hand hygiene compliance, the Buddy Badge System helps reduce the incidence of healthcare-associated infections, including surgical site infections. **Integration with Electronic Health Records (EHR):** The system will be integrated in the near future to existing EHR systems. This integration will provide for an analysis of individual patient infection risk and better-informed decision-making.
7. **Customizable reports:** Healthcare facilities can generate customizable reports based on specific needs and preferences. These reports can be used for internal audits, compliance reviews, and presentations to stakeholders. The flexibility in reporting ensures that the system meets the unique requirements of each facility.

The Buddy Badge System's metrics provide a comprehensive view of hand hygiene practices, enabling healthcare facilities to maintain high standards of infection control. By leveraging data-driven insights and real-time feedback, the system empowers caregivers to consistently adhere to hand hygiene protocols.

Practice changes

Implementing the Buddy Badge System requires few practice changes, all designed to seamlessly integrate into the daily routines of healthcare workers without adding extra burdens. The system's intuitive design and user-friendly features ensure that caregivers can prioritize patient care while adhering to hand hygiene protocols:

1. **Seamless integration with daily routines:** The Buddy Badge System is designed to fit naturally into the existing workflows of healthcare workers. By providing real-time prompts and feedback, it ensures that hand hygiene is performed without disrupting the caregiver's routine. The system's intuitive design means that caregivers can quickly adapt to its use, maintaining high hygiene standards with minimal effort. For example, if a caregiver completes a shift with no missed opportunities then they will receive no prompts.
2. **Customized protocols for different roles:** The system allows for the customization of hand hygiene protocols based on the caregiver's role. For example, allied healthcare workers and nurses may have different hand hygiene requirements, and the Buddy Badge System can accommodate these variations. This customization ensures that all staff members follow protocols that are relevant to their specific duties, enhancing overall compliance.
3. **Efficient use of time:** When hand hygiene is completed, the badge glows green for 60 to 80 seconds, allowing caregivers to move between patient environments without additional prompts. This feature reduces the time spent on hand hygiene actions while ensuring compliance, making it easier for caregivers to maintain high standards without feeling rushed.
4. **Minimizing disruptions:** The Buddy Badge System is equipped with features that minimize disruptions to the caregiver's workflow. For instance,

if a caregiver enters a patient room without touching anything and exits within 20 seconds (for example if the room is found to be unoccupied), no missed opportunities are recorded.

5. **Adaptive prompts:** The system's prompts are designed to be discreet and non-intrusive. The Buddy Badge vibrates gently to remind caregivers to perform hand hygiene, and the vibration can be adjusted to ensure it does not disturb patients sleeping at night.
6. **Support for congregate spaces:** In settings such as long-term care facilities, much of the care is provided outside of resident rooms in congregate spaces. The Buddy Badge System can be configured to provide interval prompting, reminding caregivers to perform hand hygiene at regular intervals. This feature ensures that hand hygiene standards are maintained even in more flexible environments.
7. **Tailored for surgical units:** The system's features, along with potential new enhancements, can be customized to meet the specific requirements of specialized units including surgical units.
8. **Implementation and maintenance:** Hygienic Echo takes care of the system's implementation and maintenance with minimal involvement from the facility's staff. This approach ensures that the system is set up efficiently and continues to operate smoothly, allowing caregivers to focus on patient care.

By integrating seamlessly into existing routines and providing discreet, adaptive prompts, the Buddy Badge System ensures that caregivers can maintain high hand hygiene standards without added burden. This user-friendly approach fosters a culture of compliance, accountability, and positivity, ultimately enhancing patient safety and reducing the risk of infections.

Implementation

The implementation of the Buddy Badge System involves a series of well-coordinated steps to ensure a smooth transition and seamless integration into the healthcare facility's operations. Hygienic Echo provides comprehensive support throughout the process, minimizing disruption to daily routines and ensuring that the system is fully functional from day one.

1. **Stakeholder engagement:** Successful implementation begins with engaging key stakeholders, including Infection Control, Surgery, Anesthesia, Peri-Operative Care, Medical Device Reprocessing Department, and Environmental Services. These stakeholders play a crucial role in tailoring the system to meet the specific needs of the facility.
2. **Site assessment:** A thorough site assessment is conducted to identify the optimal locations for installing kiosks, zone markers, and dispenser counters. This ensures that the system is strategically placed to maximize coverage and effectiveness. The assessment also considers the facility's layout and healthcare team's workflow patterns to minimize disruption.
3. **System installation:** The installation process is designed to be quick and non-disruptive. Zone markers and dispenser counters are battery-powered and can be attached with self-tapping screws, eliminating the need for complex wiring or IT integration. This straightforward installation process ensures that the system is up and running with minimal downtime.
4. **Training and onboarding:** Comprehensive training is provided to all staff members to ensure they are comfortable using the Buddy Badge System. Training sessions include demonstrations on picking up and returning badges, interpreting prompts, and responding to real-time feedback. This hands-on training approach ensures all users are confident using the system effectively.
5. **Initial setup and customization:** The system is customized to align with the facility's specific protocols and workflows. This includes setting the duration of the green light period, configuring prompts for different types of spaces, and adjusting the intensity of vibrations. Customization ensures that the system supports the unique needs of the facility and its caregivers.
6. **Ongoing support and maintenance:** Hygienic Echo provides ongoing support to ensure that the system remains fully operational. This includes periodic maintenance checks, battery replacements, and software updates. The support team is readily available to address any issues and provide assistance as needed, ensuring that the system continues to deliver optimal performance.
7. **Monitoring and evaluation:** Once the system is installed, continuous monitoring is conducted to evaluate its effectiveness. This includes tracking compliance rates, missed opportunities, and infection rates. Regular reports are generated to provide insights into performance and identify areas for improvement. This data-driven approach ensures that the system remains effective and supports continuous improvement.
8. **Feedback and improvement:** Feedback from users is actively sought to identify any challenges or areas for enhancement. This feedback is then used to make iterative improvements to the system, ensuring it continues to meet the needs of the facility and its caregivers. Regular communication with stakeholders ensures that the system evolves in line with their requirements.

By providing comprehensive support and minimizing disruption, Hygienic Echo ensures that the implementation of the Buddy Badge System is smooth and efficient. The system's customization options and ongoing support make it a valuable tool for enhancing hand hygiene compliance, and reducing the risk of infections in healthcare settings.

Impact on healthcare personnel workflow

The Buddy Badge System is designed to integrate seamlessly into the daily routines

of healthcare personnel, ensuring that hand hygiene compliance is maintained without adding additional burdens. The system's intuitive design means that staff can quickly adopt its use, with minimal training required. Caregivers follow their usual practice of performing hand hygiene before entering or exiting a patient's environment. The system provides real-time feedback, with the badge glowing green for 60 to 80 seconds after hand hygiene is performed, allowing caregivers to move between patient environments without additional prompts. This feature ensures that hand hygiene actions are performed efficiently, reducing the time spent on these tasks while maintaining high compliance standards.

The system's adaptive prompts are designed to be discreet and non-intrusive, ensuring that caregivers can focus on patient care without unnecessary interruptions. The Buddy Badge vibrates gently to remind caregivers to perform hand hygiene only when it has been missed.

Maintenance implications

The Buddy Badge System is designed to be low-maintenance. Hygienic Echo provides ongoing support, including periodic maintenance checks, battery replacements, and software updates.

New processes involved

Implementing the Buddy Badge System involves a few new processes, all designed to enhance hand hygiene compliance without adding additional burdens to caregivers. These processes include:

1. **Picking up and returning badges:** Caregivers pick up their Buddy Badge at the beginning of their shift by scanning their personal QR code at the kiosk. The badge is then automatically personalized for their use, ensuring that all hand hygiene actions are accurately tracked. At the end of their shift, caregivers return the badge to the kiosk for data upload and recharging, ready for the next use.
2. **Real-time feedback and alerts:** The system provides real-time feedback and alerts. When a caregiver fails to perform hand hygiene, the system immediately prompts them with a vibration. This immediate feedback loop helps instill better hygiene habits and ensures compliance in critical moments.
3. **Customizable protocols:** The Buddy Badge System allows for the customization of hand hygiene protocols based on the caregiver's role and the specific needs of the facility. This customization ensures that all staff members follow protocols that are relevant to their specific duties, enhancing overall compliance.
4. **Data integration and reporting:** Customizable reports can be generated based on specific needs and preferences, providing valuable insights for internal audits, compliance reviews, and presentations to stakeholders.
5. **Gamification and positive reinforcement:** The Buddy Badge System incorporates gamification elements to encourage high compliance. Caregivers receive rewards, such as gift cards, for maintaining high hygiene standards. This positive reinforcement has been shown to significantly boost compliance rates, creating a culture of positivity, excellence and accountability within the healthcare facility.

The Buddy Badge System's

implementation brings numerous benefits to healthcare environments. By integrating seamlessly into existing workflows and providing real-time feedback and data-driven insights, the system enhances hand hygiene practices, reduces the risk of infections, and improves overall patient safety. Its low-maintenance design ensures that it remains operational with minimal intervention, making it a valuable tool for healthcare facilities committed to maintaining the highest standards of hygiene.

In conclusion, the Buddy Badge System by Hygienic Echo represents a significant advancement in hand hygiene compliance technology. Its innovative use of AI, wearable and sensing technologies, combined with real-time feedback and gamification, sets it apart from other systems currently available. Ongoing research and development ensure that the system remains at the cutting edge of technology, providing healthcare facilities with the tools they need to maintain the highest standards of hygiene.

Contact Information

www.hygienicecho.com

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