STERYBOX Continuous Enclosed UV-C Air Disinfection as a Complementary Infection-Control Strategy for Intensive Care Units in Hong Kong.

Scientific Rationale with Specific Reference to Acinetobacter baumannii, Klebsiella pneumoniae, Pseudomonas aeruginosa and Staphylococcus aureus / MRSA

1. Introduction

Intensive Care Units (ICUs) represent one of the most critical environments for infection prevention and control. ICU patients are frequently exposed to invasive procedures, mechanical ventilation, central venous catheters, urinary catheters, prolonged hospitalization, broad-spectrum antibiotics and immunological vulnerability. These factors increase the risk of healthcare-associated infections (HAIs), including infections caused by multidrug-resistant organisms.

In Hong Kong, the public acute-care system is highly concentrated and clinically advanced. Published data describe acute admissions in Hong Kong's public healthcare system as being managed across 23 acute hospitals, supported by 15 general adult ICUs. This makes the ICU sector a focused and highly relevant clinical environment for complementary infection-control technologies.

The pathogens specifically mentioned by the ICU nurse — Acinetobacter baumannii, Klebsiella pneumoniae, Pseudomonas aeruginosa and Staphylococcus aureus / MRSA — are all clinically important hospital organisms and are frequently associated with high-risk wards, ICU patients, ventilator-associated pneumonia, bloodstream infections, environmental contamination and antimicrobial resistance.

STERYBOX is not intended to replace standard ICU infection-control procedures. Rather, it should be positioned as a complementary continuous air-disinfection system, designed to reduce airborne microbial contamination in occupied healthcare environments through enclosed UV-C germicidal irradiation.

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2. Why These Pathogens Are Relevant in ICU Environments

2.1 Acinetobacter baumannii

Acinetobacter baumannii is a major ICU-related pathogen, particularly because of its environmental persistence and frequent association with antimicrobial resistance, including carbapenem resistance. It can survive on dry surfaces and hospital equipment and is associated with ventilator-associated pneumonia, bloodstream infections, wound infections and outbreaks in critical-care settings.

Although Acinetobacter baumannii is often discussed as a surface-persistent pathogen, environmental contamination and aerosol-generating procedures can contribute to its

spread in high-risk hospital areas. For this reason, any strategy that reduces microbial burden in the clinical environment may be relevant as part of a wider infection-control programme.

2.2 Klebsiella pneumoniae

Klebsiella pneumoniae is an important Gram-negative pathogen associated with pneumonia, bloodstream infections, urinary tract infections and device-related infections. In ICU settings, carbapenemase-producing Klebsiella pneumoniae, including KPC-producing strains, is of particular concern because therapeutic options may be limited.

Published UV-C studies have specifically included Klebsiella pneumoniae KPC strains, confirming that antibiotic resistance mechanisms do not prevent susceptibility to UV-C irradiation.

2.3 Pseudomonas aeruginosa

Pseudomonas aeruginosa is a clinically relevant opportunistic pathogen in ICUs and is associated with ventilator-associated pneumonia, bloodstream infections, burn and wound infections, and colonization of humid hospital environments. It is also an important antimicrobial-resistant Gram-negative organism.

For STERYBOX, Pseudomonas aeruginosa is particularly important because it is included in direct STERYBOX microbiological testing, providing device-specific evidence of germicidal activity under controlled test conditions.

2.4 Staphylococcus aureus and MRSA

Staphylococcus aureus is a major cause of healthcare-associated infections. Methicillin-resistant Staphylococcus aureus, or MRSA, is especially relevant in hospitals because resistance to beta-lactam antibiotics limits treatment options and increases infection-control complexity.

STERYBOX documentation includes direct testing against Staphylococcus aureus ATCC 6538. Published UV-C studies also confirm susceptibility of MRSA to UV-C irradiation.

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3. Direct STERYBOX Microbiological Evidence

STERYBOX has been independently tested against selected microorganisms under controlled microbiological conditions. The test panel includes:

- Pseudomonas aeruginosa ATCC 9027
- Staphylococcus aureus ATCC 6538
- Salmonella bony
- Listeria innocua
- Aspergillus niger
- Candida albicans

The available STERYBOX scientific documentation reports strong reductions in airborne contamination under controlled conditions, including up to 99.99% airborne contamination reduction within 30 minutes in laboratory testing, and more than 95% airborne bacterial reduction in hospital-environment testing.
Therefore, for two of the organisms specifically requested by the ICU nurse — Pseudomonas aeruginosa and Staphylococcus aureus — there is direct STERYBOX-specific microbiological evidence.
For MRSA, Klebsiella pneumoniae and Acinetobacter baumannii, the scientific support comes from published UV-C literature showing susceptibility of these organisms, including multidrug-resistant strains, to UV-C irradiation.

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4. Published UV-C Evidence for the Requested ICU Pathogens

4.1 UV-C and multidrug-resistant hospital pathogens

Russo et al. investigated the effect of UV-C irradiation on several multidrug-resistant hospital pathogens, including:

- Staphylococcus aureus
- MRSA
- Pseudomonas aeruginosa
- Klebsiella pneumoniae KPC

This publication is highly relevant because it specifically addresses UV-C efficacy against organisms comparable to those mentioned by the ICU nurse and includes antibiotic-resistant strains of hospital concern.
Reference:
Russo C. et al. “Effect of a UV-C Automatic Last-Generation Mobile Robotic System on Multi-Drug Resistant Pathogens.” International Journal of Environmental Research and Public Health, 2021; 18(24):13019. DOI: 10.3390/ijerph182413019.

4.2 UV-C and Acinetobacter baumannii

Rastogi, Wallace and Smith investigated the disinfection of Acinetobacter baumannii-contaminated surfaces relevant to medical treatment facilities using ultraviolet C light. The study confirms that Acinetobacter baumannii can be effectively inactivated by UV-C irradiation under experimental conditions.
Reference:
Rastogi V.K., Wallace L., Smith L.S. “Disinfection of Acinetobacter baumannii-contaminated surfaces relevant to medical treatment facilities with ultraviolet C light.” Military Medicine, 2007; 172(11):1166–1169. DOI: 10.7205/MILMED.172.11.1166.

4.3 UV-C and airborne Pseudomonas aeruginosa

Published research has also evaluated UV-C irradiation against airborne Pseudomonas aeruginosa, which is particularly relevant for air-disinfection systems. This supports the

general scientific principle that UV-C irradiation can reduce viability of airborne bacterial contamination when dose, exposure time and airflow conditions are adequate.

Reference:

Nguyen T.T. et al. “The Effectiveness of Ultraviolet-C (UV-C) Irradiation on the Viability of Airborne Pseudomonas aeruginosa.” International Journal of Environmental Research and Public Health, 2022. DOI: 10.3390/ijerph192013706.

4.4 UV-C and hospital-interest biofilms / resistant bacteria

More recent literature continues to support the antimicrobial relevance of UV-C against hospital-interest microorganisms, including biofilm-forming organisms and antibiotic-resistant bacteria. Although surface/biofilm studies cannot be directly translated into air-disinfection performance, they reinforce the biological susceptibility of clinically relevant pathogens to UV-C irradiation.

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5. Why Antibiotic Resistance Does Not Mean UV-C Resistance

It is important to clarify a key scientific point for ICU staff.

Antibiotic resistance — for example MRSA, KPC-producing Klebsiella pneumoniae, carbapenem-resistant Acinetobacter baumannii or multidrug-resistant Pseudomonas aeruginosa — does not mean that the microorganism is resistant to UV-C irradiation in the same way.

Antibiotic resistance usually depends on biochemical or structural mechanisms such as:

- antibiotic-degrading enzymes,
- altered drug targets,
- efflux pumps,
- reduced membrane permeability,
- biofilm-associated tolerance.

UV-C irradiation acts through a different mechanism. It damages nucleic acids and other cellular targets, preventing microbial replication and viability when an adequate UV-C dose is delivered.

Therefore, multidrug-resistant bacteria can remain susceptible to UV-C irradiation. This is one of the reasons why UV-C is scientifically relevant as an environmental disinfection technology in hospitals, including ICUs.

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6. STERYBOX Technology and ICU Relevance

STERYBOX uses enclosed UV-C germicidal irradiation at 254 nm inside the unit. Air from the room is continuously drawn into the device, exposed to UV-C radiation inside the patented UV-CHRIS high-reflecting coil system, and then recirculated into the room.

The ICU-relevant features are:

1. Continuous air treatment
   STERYBOX can operate continuously, reducing airborne microbial burden over time rather than acting only as an intermittent cleaning procedure.
2. Use in occupied rooms
   UV-C radiation is confined inside the unit, allowing operation while patients, nurses, doctors and visitors are present.
3. Complementary infection-control role
   STERYBOX does not replace hand hygiene, PPE, surface cleaning, ventilation, isolation procedures, antimicrobial stewardship or hospital protocols. It supports them by acting on the airborne microbial component.
4. No direct UV-C exposure to staff or patients
   Unlike open UV-C room disinfection systems, enclosed UV-C systems are designed to avoid direct exposure of occupants to UV-C radiation.
5. No filter-based microbial accumulation
   STERYBOX does not rely primarily on microbial capture in filters. Its principle is UV-C inactivation inside the device.
6. Specific relevance for high-risk wards
   ICU, isolation rooms, emergency departments, respiratory wards, staff rooms and high-density clinical areas are logical environments for complementary continuous air disinfection.

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7. Hong Kong ICU Context

Hong Kong has a dense healthcare system and a strong infection-control culture due to previous respiratory outbreaks and the operational pressure of seasonal influenza. Published data identify 15 adult ICUs in publicly funded hospitals in Hong Kong, supporting acute admissions across the public hospital network.

This matters commercially and clinically because the ICU market is concentrated and clinically influential. Successful positioning in ICU departments may also support broader adoption in:

- isolation rooms,
- respiratory wards,
- emergency departments,
- high-dependency units,
- staff rooms,
- waiting areas,
- outpatient clinics,
- dental clinics inside hospital facilities.

For Hong Kong, STERYBOX can be positioned not only as a technology for general air hygiene, but as a complementary engineering control for healthcare environments where antimicrobial-resistant organisms and seasonal respiratory infections are both operational concerns.

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8. Staff Illness, Absenteeism and Economic Impact

ICU infection-control decisions are usually evaluated primarily from a patient-safety perspective. However, workforce continuity is also highly relevant. Seasonal respiratory infections can cause sickness absence, presenteeism, overtime, replacement staffing, scheduling disruption and reduced clinical capacity.

Hong Kong-specific healthcare-worker data show that influenza epidemics were associated with increased sickness absence and productivity loss among healthcare workers. Studies on Hong Kong acute-care hospitals also indicate that nurses frequently report sickness presenteeism, meaning that staff may continue working while ill, with reduced productivity and potential infection-transmission implications.

This economic argument should be presented carefully. STERYBOX should not be claimed to guarantee a specific reduction in sick leave. However, it is scientifically reasonable to state that continuous reduction of airborne microbial contamination may support broader infection-control strategies aimed at reducing exposure to respiratory pathogens, with potential operational benefits.

A practical conservative model for hospitals is:

- respiratory infections cause staff absence and presenteeism;
- airborne transmission contributes to respiratory infection spread in indoor environments;
- ventilation, masking, hand hygiene and air disinfection reduce exposure risk through different mechanisms;
- STERYBOX contributes at the environmental-air level by continuously reducing airborne microbial burden.

Therefore, STERYBOX may provide a dual value proposition:

1. Clinical value
   Complementary reduction of airborne microbial contamination in high-risk hospital environments.
2. Economic and operational value
   Potential support for reducing avoidable staff illness, sick leave, presenteeism, replacement costs and seasonal workforce disruption.

This is especially relevant in ICUs, where staff absence has a higher operational impact than in many other hospital departments because skilled replacement staff are limited and nurse-to-patient ratios are critical.

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9. Correct Scientific Positioning for ICU Staff

For ICU professionals, the safest and most credible message is:

STERYBOX is a complementary continuous enclosed UV-C air-disinfection system. Its direct microbiological testing supports activity against Pseudomonas aeruginosa and Staphylococcus aureus. Published UV-C literature supports susceptibility of MRSA, Klebsiella pneumoniae, including resistant strains, Pseudomonas aeruginosa and Acinetobacter baumannii to UV-C irradiation. Because STERYBOX applies enclosed UV-C irradiation to continuously recirculated room air, it is scientifically reasonable to position it as a complementary air-disinfection technology for ICU environments where these pathogens are clinically relevant.

It should also be clearly stated that:

- STERYBOX does not replace standard ICU infection-control procedures.
- It does not replace ventilation requirements.
- It does not replace surface disinfection or hand hygiene.
- It does not replace PPE or isolation protocols.
- It should be integrated into existing infection-control programs.

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10. Suggested Answer to the ICU request

Yes. The microorganisms mentioned — Acinetobacter baumannii, Klebsiella pneumoniae, Pseudomonas aeruginosa and Staphylococcus aureus / MRSA — are clinically relevant ICU pathogens and are among the organisms for which UV-C disinfection is scientifically relevant.

For STERYBOX specifically, independent microbiological tests directly include Pseudomonas aeruginosa ATCC 9027 and Staphylococcus aureus ATCC 6538, with strong germicidal reduction under controlled conditions.

For MRSA, Klebsiella pneumoniae, including resistant KPC strains, and Acinetobacter baumannii, published scientific literature confirms susceptibility to UV-C irradiation. Importantly, antibiotic resistance does not make these bacteria resistant to UV-C irradiation, because UV-C acts through physical damage to microbial genetic material rather than through antibiotic drug mechanisms.

STERYBOX uses enclosed 254 nm UV-C irradiation inside the unit, combined with continuous room-air recirculation through the patented UV-CHRIS high-reflecting coil system. This allows continuous air disinfection while the room remains occupied, without direct UV-C exposure to patients or staff.

Therefore, STERYBOX can be scientifically presented as a complementary air-disinfection system for ICU environments, supporting standard infection-control measures by continuously reducing airborne microbial contamination.

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11. Documents Available for Review

The following STERYBOX documents should be provided to the hospital / ICU team:

1. STERYBOX Complete Scientific Essay 2024
2. Scientific Report Summary on STERYBOX 2025
3. STERYBOX FAQ EN 2025
4. STERYBOX technical and microbiological test documentation
5. STERYBOX ozone test documentation
6. STERYBOX hospital-environment bacterial reduction test documentation

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12. Conclusion

The available evidence supports a strong but scientifically prudent positioning of STERYBOX for ICU use in Hong Kong.

The strongest argument is not that STERYBOX replaces ICU infection-control procedures, but that it adds a continuous environmental air-disinfection layer to existing protocols.

This is particularly relevant in Hong Kong ICUs because:

- ICU patients are highly vulnerable;
- multidrug-resistant pathogens are clinically important;
- Acinetobacter baumannii, Klebsiella pneumoniae, Pseudomonas aeruginosa and MRSA are relevant hospital organisms;
- UV-C literature supports susceptibility of these organisms to irradiation;
- STERYBOX has direct test evidence for Pseudomonas aeruginosa and Staphylococcus aureus;
- continuous air disinfection may also support workforce continuity by reducing exposure to seasonal respiratory pathogens.

For these reasons, STERYBOX can be credibly proposed as a complementary continuous UV-C air-disinfection technology for ICU, isolation and high-risk clinical environments in Hong Kong.