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### Continuous Disinfection of the Hospital Environment

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#### Using High-Intensity Narrow Spectrum Light (HNS-Light)

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**Increased awareness of the importance of the hospital environment as a potential source of nosocomial pathogens has led to an upsurge of interest in hospital cleaning and decontamination procedures and technologies. It is now known that certain pathogens, such as MRSA and Acinetobacter can survive for many months on environmental surfaces within the hospital environment. Although conventional surface cleaning and disinfection will always be essential for both aesthetic and functional reasons, many current practices and procedures have limited effectiveness for pathogen removal.**

Inevitably there will be some areas that are either not cleaned or only ineffectively cleaned. Also, because microorganisms are continuously shed and dispersed from patients and staff, routine cleaning procedures may not be sufficiently frequent to effect timely removal. It is also the case that some of the most frequently touched and heavily contaminated surfaces are those least frequently cleaned. Domestic cleaning staff are not allowed to clean electronic equipment or items attached to patients and these cleaning tasks may be left to nurses who are often too busy. These limitations have led to calls for enhanced investment in more effective conventional cleaning as well to encourage the development of new technologies that might be used to supplement conventional cleaning and disinfection procedures.

A new technology, developed at The Robertson Trust Laboratory for Electronic Sterilisation Technologies (ROLEST) at the University of Strathclyde, has been introduced to provide a unique new approach to help address these problems. This is a new light-based disinfection method based on the use of what the ROLEST research group have termed "High Intensity Narrow Spectrum Light (HINS-light)" which is a violet coloured light from within the visible spectrum that is highly bactericidal. This has formed the basis for the development of the High-Intensity Narrow-Spectrum Light Environmental Decontamination System (HINS-light EDS) specifically designed for the reduction of environmental bacterial contamination in hospitals and other areas of the healthcare environment.

The High Intensity Narrow Spectrum (HINS) light is a narrow bandwidth of high intensity visible violet light with peak output at 405nm. These specific light wavelengths exploited by the HINS-light EDS technology photo-excite molecules which induce the production of free radical molecules, such as the highly reactive singlet oxygen, within the exposed bacteria. This photodynamic reaction ultimately leads to irreversible inactivation of bacterial cells. This approach to antimicrobial treatment is effective against a wide range of bacterial pathogens including those that are commonly associated with HAIs. The disinfection treatment can be continuously applied to air and all exposed surfaces.

#### Deployment to Inactivate Hospital Bacteria

The HINS-light EDS units are ceiling mounted light sources that are typically operated continuously during daylight hours (in synchrony with hospital lighting) within the ward or isolation room to provide ongoing environmental decontamination with no disruption of normal day-to-day hospital procedures. Whilst HINS-light is highly bactericidal, safety analysis of the complete wavelength emission spectrum of the light from the HINS-light EDS, with reference to relevant international guidelines, confirms the safety of the HINS-light EDS sources for clinical use.

Operational benefits of the HINS-light EDS include:

- Continuous disinfection;
- Treats the visible environment (air and surfaces);
- Safe for use in the presence of people;
- Effective against a wide range of pathogens;
- Little/no operational requirements;
- No user training;
- No problems with staff/patient compliance; and
- No chemicals or chemical pre-treatments.
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## Clinical Evaluation Results

Since mid 2008, the ROLEST Group in collaboration with infection control experts from Glasgow Royal Infirmary (GRI), have been engaged in clinical evaluation of the HINSlight EDS. Most of this work has been funded by a substantial Scottish Enterprise Proof of Concept Award that enabled the ROLEST researchers to develop the HINS-light EDS from concept to practical application, culminating in its clinical evaluation.

The clinical evaluation was designed to assess the effectiveness of the HINS-light EDS for the reduction of environmental bacterial contamination on surfaces at various sites in hospital isolation rooms within the Vascular Ward, the Burns Unit and the Intensive Treatment Unit (ITU). Within the isolation rooms, the HINS-light EDS units were installed as ceiling mounted LED lighting systems, with the output level of the HINS-light EDS being set to provide effective environmental decontamination whilst being non-disturbing to patients and staff. During the evaluations the HINS-light EDS was used as a complementary disinfection procedure, being operated continuously during daylight hours in occupied rooms, under conditions where normal clinical care and infection control measures were implemented.

The effect of HINS-light EDS was assessed through contact-plate sampling of bacterial levels on a wide range of frequently touched contact surfaces (e.g. bedside locker, bed table, bed rails, chair, bin lids, light switches and door handles). In each of these studies the principal objective was to assess the percentage change in bacterial contamination level in the isolation room, and whether it significantly increased or decreased following switching on or switching off the HINS-light EDS.

The findings of the clinical evaluations show clear evidence that HINS-light EDS treatment causes a reduction in bacterial counts, and that when the HINS-light EDS treatment is withdrawn, bacterial counts increase. The mean percentage reduction in total staphylococcal counts and presumptive *s. aureus* counts arising from the use of HINS-EDS was 57 percent with 95 percent confidence interval (45 to 69 percent), and 60 percent with 95 percent confidence interval (50 to 70 percent), respectively. The mean percentage increase in total staphylococcal counts and presumptive *s. aureus* counts arising from withdrawal of the HINS-light EDS treatment was 162 percent with 95 percent confidence interval (46 to 278 percent), and 168 percent with 95 percent confidence interval (-2 to 339 percent), respectively.

Additional studies carried out to further validate the efficacy of the HINS-light EDS included a study on an unoccupied isolation room in which the total staphylococcal environmental contamination level was reduced by more than 90 percent, and a study which used the HINS-light EDS over an extended period in an occupied isolation room, resulting in 86 percent reduction in staphylococcal contamination. Further studies have continued to generate convincing evidence of the decontamination efficacy of the HINSlight EDS in both isolation room settings, and additionally in out-patient clinic settings.

The study results and associated statistical analyses show clear evidence that use of the HINS-light EDS causes a reduction in environmental bacterial contamination and that the benefit derived from the treatment is lost after the HINS-light EDS treatment is withdrawn, with the bacterial contamination levels increasing over time to at least the pretreatment values. It should be borne in mind that these results were achieved under a range of clinical conditions within a busy city hospital environment, and it is important to stress that the bacterial reductions obtained were over and above those achieved by the hospital's normal stringent infection control procedures which remained fully in place throughout the study. Results from some of the studies representative of this clinical evaluation have recently been published in *The Journal of Hospital Infection* (Maclean et al, Environmental decontamination of a hospital isolation room using high-intensity narrow-spectrum light, 76, p247-251, 2010).

It is also important to note that whilst the studies described focused on the reduction of staphylococcal bacteria, levels of other contaminant bacteria will also have been concurrently reduced due to the broad spectrum bactericidal effects of HINS-light. Extensive laboratory studies by the ROLEST group have established that the HINS-light EDS is an effective technology for the inactivation of a wide range of bacterial pathogens. Staphylococcal bacteria were chosen as "efficacy indicator" bacteria because of both their importance as a cause of HAI as well as the availability of an accepted and well-tested contact agar evaluation protocol that could be applied for the accurate assessment of levels of these organisms on contact surfaces in the clinical environment. In more recent testing of the microbiocidal efficacy of HINS-light it has been established that, in addition to broad spectrum bactericidal effects, HINS-light also has biocidal effects on mould and yeast type fungi, organisms which can also cause serious problems in the clinical environment.

## Conclusions

Findings of the clinical evaluations have provided rigorous evidence that HINS-light EDS used in the treatment of occupied hospital rooms reduces total staphylococcal and presumptive staphylococcus aureus contamination levels. The findings reflect consistency across the different studies and are robust to a range of statistical analyses. In view of the studies having been conducted under hospital management conditions, where contamination levels are variable and are constantly being driven down by normal infection control procedures, the HINS-light EDS findings are externally valid and indicate that HINS-light EDS can make an additional significant contribution to bacterial decontamination in clinical environments.

A particular advantage associated with the use of HINS-light EDS is that it can be used continuously in the presence of patients and staff including during periods of high bacterial dispersion as can be associated with activities such as bed making and bandage changing. The pervasive nature of light permits treatment of all exposed surfaces and these are surfaces that are most likely to be contaminated through aerial dispersal and hand touch. The facility for continuous application is also advantageous since technologies such as deep cleaning procedures which, although highly appropriate for terminal cleaning operations, are ineffective as a means of continuous decontamination as rapid recontamination of the environment follows within several days after deep cleaning.

Whilst the results achieved with the HINSlight EDS are highly promising it has still to be established, as is the case with all other environmental decontamination procedures, whether long-term use of the HINS-light EDS can have a significant impact on clinical outcomes such as infection and colonisation rates.

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