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An Innovation: Decontamination by Light

HINS-light Environmental Decontamination System

A new method for pathogen control in the clinical environment

Dr Michelle Maclean, Prof Scott J MacGregor, Prof John G Anderson, Prof Gerry Woolsey

The Robertson Trust Laboratory for Electronic Sterilisation Technologies
University of Strathclyde, Glasgow

ROLEST FACILITY

The Robertson Trust Laboratory for Electronic Sterilisation Technologies

• Research into electrically-based sterilisation and inactivation technologies began in 1998 as an interdisciplinary initiative

• The Robertson Trust Laboratory for Electronic Sterilisation Technologies (ROLEST) was established in 2003 as a unique interdisciplinary research facility

• Research undertaken in ROLEST combines the skills of electrical engineers, biomedical microbiologists, physicists and bioengineers

• The objective is to develop novel disinfection and sterilisation technologies for clinical, environmental and healthcare applications

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HINS-Light Environmental Decontamination System (EDS)

- Funding through a Scottish Enterprise Proof of Concept Award led to the development of a HINS-light Environmental Decontamination System (EDS) for clinical application.
- The HINS-light EDS provides continuous environmental decontamination in the presence of people
- The bactericidal effect is achieved in the air and on all surfaces exposed to the light (bedding, floor, curtains, door handles, work surfaces, etc)
- HINS-light EDS is complimentary to existing infection control measures
- Clinical evaluation of the HINS-light EDS has been carried out at Glasgow Royal Infirmary

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High Intensity Narrow Spectrum Light (HINS-light)

- *HINS-light* is a visible-light inactivation technology
- Uses violet-blue light from the visible light spectrum, with output centred on the bactericidal wavelength of 405nm
- Absorption of HINS-light wavelengths by intracellular molecules induces production of reactive oxygen species within microorganisms
- No requirement for the addition of photosensitiser molecules
- Scientific basis of the HINS-light technology validated through publication in international scientific journals
- UK patent "Inactivation of gram-positive bacteria" (GB2442705B) granted Nov 2009

Microorganisms Susceptible to 405-nm HINS-light

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Gram-Positive Bacteria

- *Staphylococcus aureus* (incl. MRSA)
- *Clostridium perfringens*
- *Clostridium difficile*
- *Enterococcus faecalis*
- *Staphylococcus epidermidis* (CONS)
- *Staphylococcus hyicus* (CONS)
- *Streptococcus pyogenes*
- *Listeria monocytogenes*
- *Bacillus cereus*
- *Mycobacterium terrae*

Bacterial Endospores

- *Bacillus cereus*
- *Clostridium difficile*

Gram-Negative Bacteria

- *Acinetobacter baumannii*
- *Pseudomonas aeruginosa*
- *Klebsiella pneumoniae*
- *Proteus vulgaris*
- *Escherichia coli*
- *Salmonella enteritidis*
- *Shigella sonnei*
- *Serratia* spp

Yeast & Filamentous Fungi

- *Aspergillus niger*
- *Candida albicans*
- *Saccharomyces cerevisiae*

* *All organisms tested to date have shown susceptibility to HINS-light*

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HINS-light EDS: Safety & Human Health

- HINS-light Environmental Decontamination Systems (EDS) have been designed to provide sufficiently intense lighting for bactericidal effect whilst being safe for human exposure

- HINS-light EDS will be non-obtrusive, and will be as safe as normal lighting

- Assessment against standards issued by the International Committee on Non-Ionising Radiation Protection (ICNIRP) and the American Association of Governmental Hygienists (AGIH) has confirmed HINS-light EDS to be harmless to humans

Expertise Involved

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HINS-light Technical Team	• **Professor Scott J MacGregor,** *Electrical Engineer* • **Professor John G Anderson,** *Biomedical Microbiologist* • **Professor Gerry Woolsey,** *Optical Physicist* • **Dr Michelle Maclean,** *Biomedical Microbiologist*
Statistics	• **Professor George Gettinby,** *Biomedical Statistician*
Clinical Collaborators	• **Professor John Coia,** *Head of Microbiological Services GGCHB* • **Sister Kate Hamilton,** *Lead Infection Control Nurse, GGCHB* • **Dr Bishan Thakker,** *Consultant Microbiologist, GRI Burns Unit* • **Mr Ian Taggart,** *Consultant Surgeon, GRI Burns Unit* • **Mr Stuart Watson,** *Consultant Surgeon, GRI Burns Units* • **Dr Malcolm Booth,** *Consultant Anaesthetist, GRI Intensive Care Unit* • **Sarah Bache,** *Trainee Surgeon, GRI Burns Unit / PhD student at UoS* • **Angela Coyle,** *Trainee Surgeon, GRI Burns Unit / MPhil student at UoS*

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HINS-light EDS deployment in hospital environment

- *Installed into occupied isolation room*
- *Switched on during normal daylight hours*
- *Provides continuous disinfection*
- *Complimentary to existing cleaning and infection control measures*
- *Aims to minimise transmission of infection from infected patients (source isolation)*

Clinical Evaluation: General Protocol

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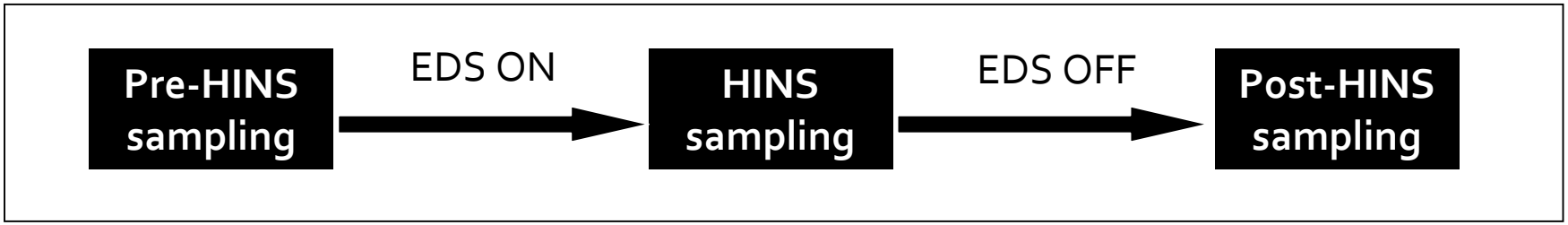
- Prototype lighting units installed into occupied isolation rooms at GRI
- Bacterial levels on surfaces within isolation rooms assessed using contact plates (300-600 plates/study)
- Sampling sites were 'frequently touched' contact surfaces
- Bacterial counts evaluated before, during and after treatment



- Studies are performed under standard NHS cleaning and containment conditions

Methodology for Clinical Evaluation

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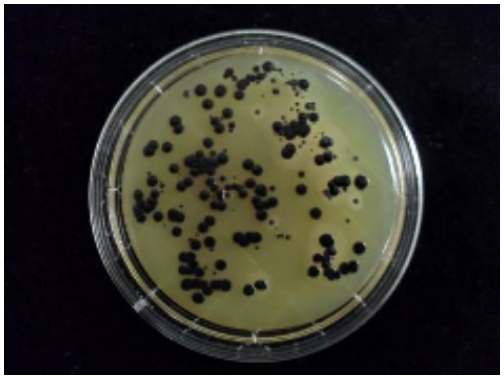
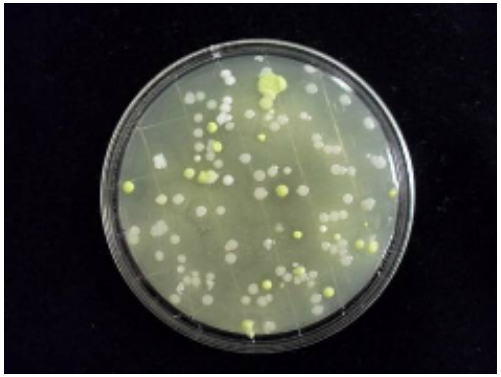


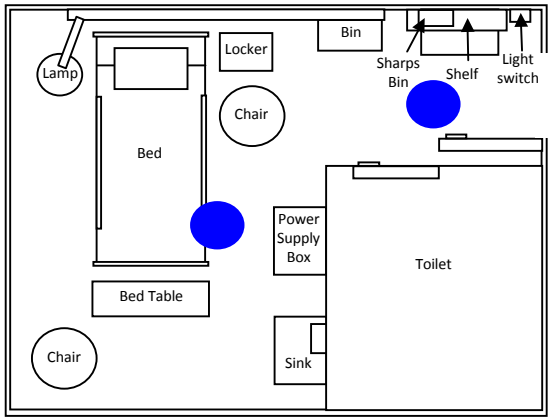
Baird Parker agar contact plate (for staphylococcal-type count)



Tryptone Soya Agar contact plate (for total viable count)

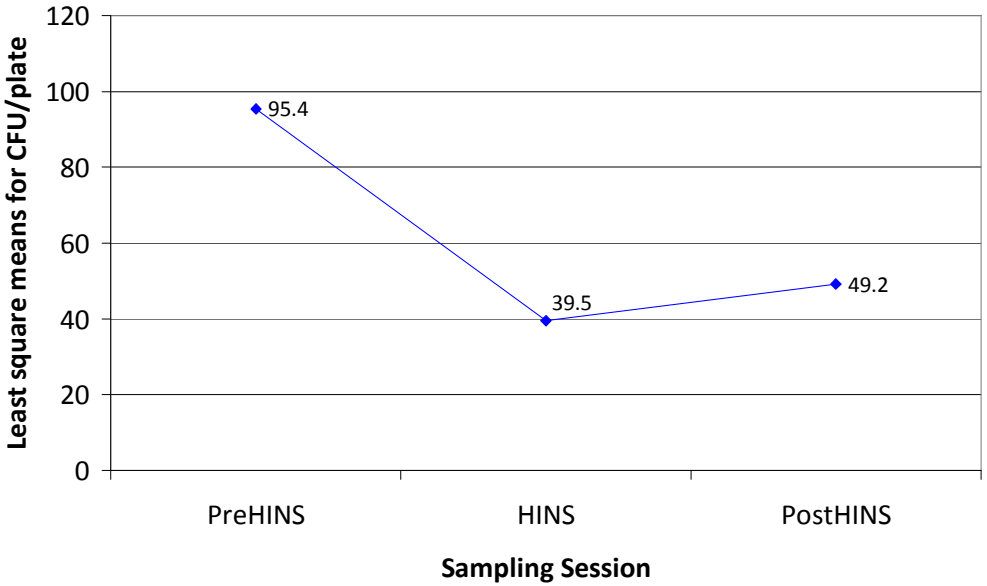
- Contact plate samples collected by NHS Infection Control Nurse
- Plates incubated and enumerated at GRI by Biomedical Scientists
- Follow-on microbiological testing of samples carried out at ROLEST
- Results independently analysed by a Biomedical Statistician

Location 1: Vascular Ward



- Isolation room within the Vascular ward was the initial location used in the clinical evaluation

- Initial investigations included the use of different sampling media & different sampling times in order to finalise protocol



HINS-light EDS on/off Intervention

- Room occupied by MRSA +ve patient
- Various surfaces sampled with BPA
- Sampling performed before, during & after use of the HINS-light EDS (i.e. PreHINS, HINS & PostHINS):

58% reduction of total staphylococci in room area

Location 2: Burns Unit

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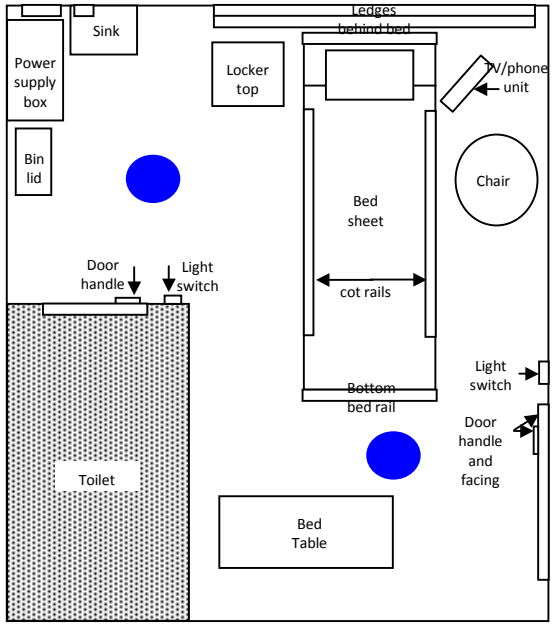
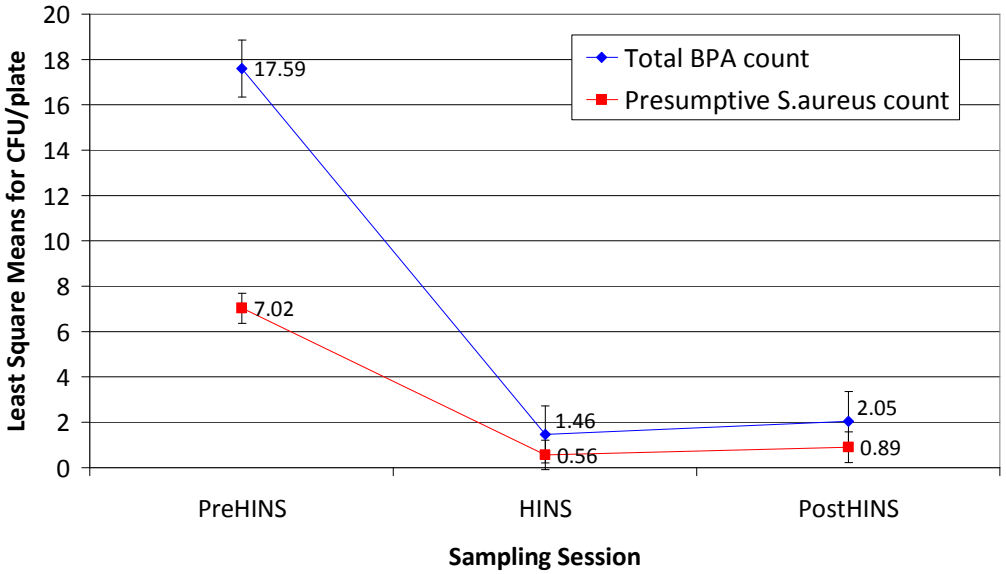


- Majority of the studies carried out in two isolation rooms in Burns Unit
- BPA used to sample various contact surfaces around the room
- Sampling performed before, during & after use of the HINS-light EDS

(i.e. PreHINS, HINS & PostHINS)

HINS-light EDS Treatment of Empty Room



- This study investigated the effect of HINS-light EDS on bacterial levels on contact surfaces in an unoccupied isolation room
- Results demonstrate that environmental bacterial levels were significantly reduced after 24hr use of HINS-light EDS:

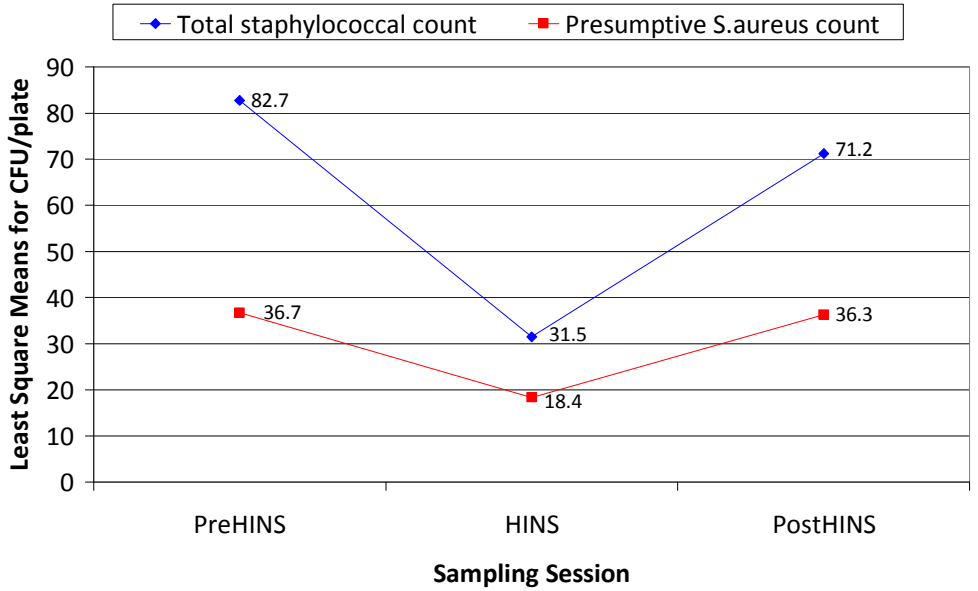
91% reduction of total staphylococci
92% reduction of presumptive S.aureus

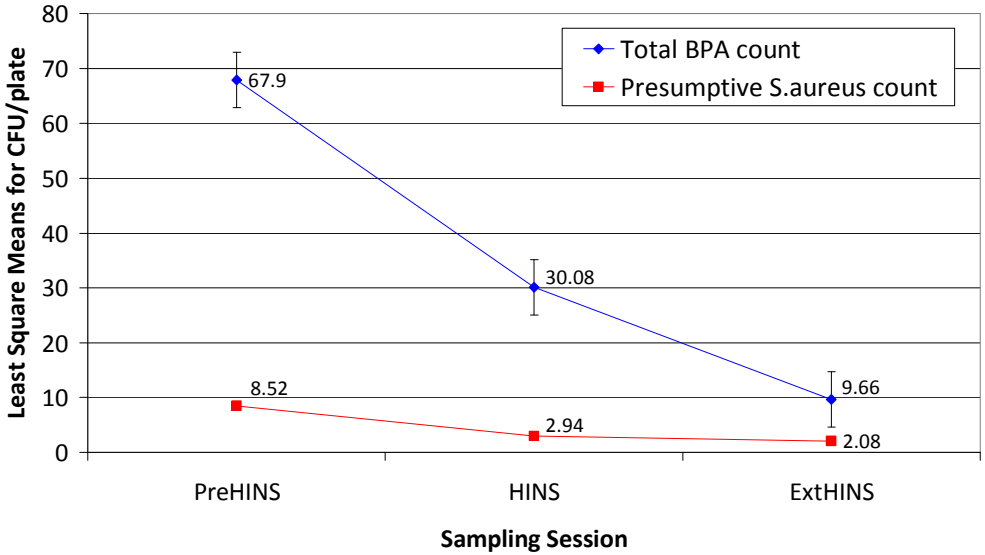
Burns Unit: HINS-light EDS Treatment of Occupied Rooms

HINS-light EDS on/off Intervention

- This study involved monitoring bacterial levels within the isolation room in the presence and absence of HINS-light
- Results show a significant reduction in bacterial levels during 5-days HINS-light EDS use:

62% reduction of total staphylococci
50% reduction of presumptive S.aureus





Extended HINS-light EDS Treatment

- This study involved extending the duration of HINS-light treatment
- Results demonstrate that environmental bacterial levels were significantly reduced over the extended treatment period (2-days plus further 3-days treatment):

86% reduction of total staphylococci
76% reduction of presumptive S.aureus

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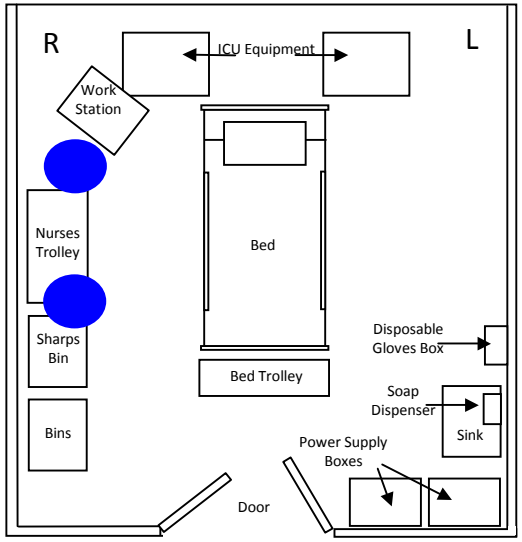
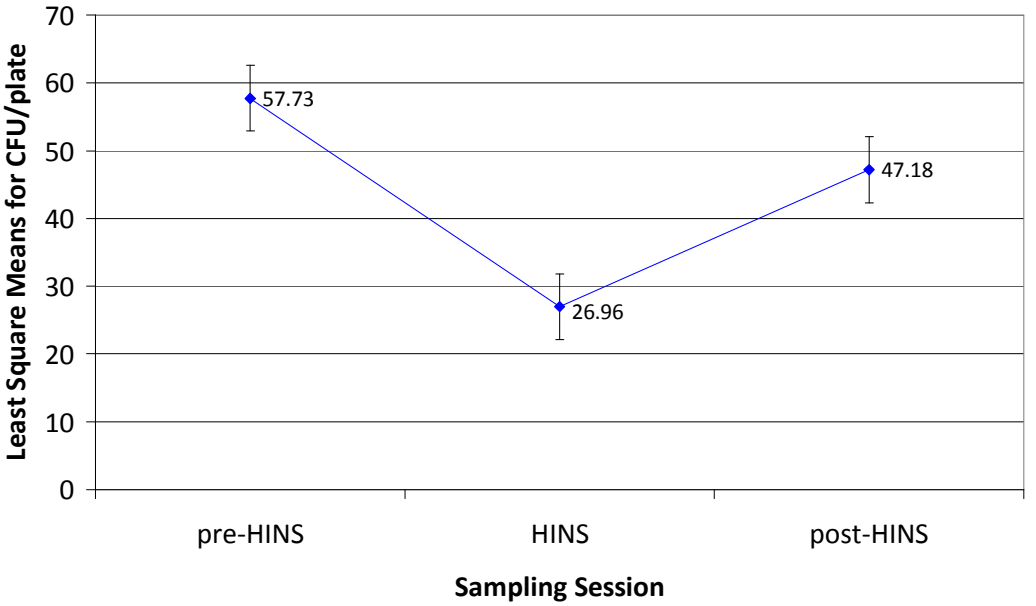
Location 3: Intensive Care Unit





- ICU is an area with high frequency of cleaning and stringent infection control procedures
- Contact surfaces were sampled with TSA plates for a total viable bacterial count
- Results demonstrate a significant reduction in environmental bacterial levels throughout the room during use of HINS-light EDS

Average 53% reduction of total viable bacteria across the whole room

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Example of Site to Site Variability

- Studies typically involved preHINS, HINS and postHINS periods during which samples are collected from sites around the room (locker top, bed table, etc.).

- Bacteria levels vary significantly from site to site, however bioburden levels are lower during the use of the HINS-light EDS.

Example results from one HINS-light EDS study in Burns Unit :

Sampling Site	Bacterial levels BEFORE use of HINS-light EDS (mean cfu/plate)	Bacterial levels AFTER use of HINS-light EDS (mean cfu/plate)	% Reduction
Patient Chair	201	38	81 %
Toilet Door Handle	158	22	86 %
Bin lid	102	9	91 %
Bed Table	25	9	64 %
TV/phone Unit	165	72	56 %

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Clinical Evaluation Overview

- Comprehensive evaluation carried out at Glasgow Royal Infirmary within Vascular Ward, Burns Unit & ICU

- Independent statistical analysis of the results demonstrates that use of the HINS-light EDS significantly reduces the environmental contamination within isolation rooms

- Reductions in environmental contamination of 30 – 90 %, with an average reduction of approximately 60%, were achieved

- All reductions were achieved over and above standard NHS cleaning and Infection Control practice

- Results confirm benefit of installation of HINS-light EDS in selected 'high- risk' areas

Publications

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Scientific Peer-Reviewed Publications on Bactericidal Effectiveness of HINS-light:

M. Maclean, S.J. MacGregor, J.G. Anderson and G.A. Woolsey, "Inactivation of Bacterial Pathogens Following Exposure to Light from a 405-nm LED Array", *Applied and Environmental Microbiology,* Volume 75(7); p1932-1937, 2009.

M. Maclean, S.J. MacGregor, J.G. Anderson and G.A. Woolsey, "The Role of Oxygen in the Visible-Light Inactivation of *Staphylococcus aureus*". *Journal of Photochemistry and Photobiology B: Biology*, Volume 92(3); p180-184, 2008.

M. Maclean, S.J. MacGregor, J.G. Anderson and G.A. Woolsey, "High-Intensity Narrow-Spectrum Light Inactivation and Wavelength Sensitivity of *Staphylococcus aureus*". *FEMS Microbiology Letters*, Volume 285 Issue 2; p227-232, 2008.

Scientific Publications on the Clinical Use of HINS-light EDS:

M. Maclean, S.J. MacGregor, J.G. Anderson, G.A. Woolsey, J.E. Coia, K. Hamilton, I. Taggart , S.B. Watson, B. Thakker and G. Gettinby, "Environmental Decontamination of a Hospital Isolation Room using High-Intensity Narrow-Spectrum Light (HINS-light)", *Journal of Hospital Infection*, Volume 76; p247-251, 2010.

S. E. Bache, M. Maclean, S. J. MacGregor, J. G. Anderson, G. Gettinby, G. A. Woolsey, J. E. Coia, S. B. Watson and I. Taggart, "Assessment of HINS-Light for Continuous Disinfection on a Burns Unit", being submitted to the *Journal of Burn Care and Research*, July 2010.

Presentations

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Clinical Conference/Meeting Presentations :

Bache S E, M. Maclean, S.J. MacGregor, J.G. Anderson, G.A. Woolsey, S. Watson, I. Taggart, J.E. Coia, K. Hamilton and G. Gettinby, "Application of a novel light technology for disinfection on the burns unit", Oral Presentation at the American Burn Associations 42nd Annual Meeting, March 9th–12th 2010, Boston, MA, USA.

Bache S E, M. Maclean, S.J. MacGregor, J.G. Anderson, G.A. Woolsey, S. Watson, I. Taggart, J.E. Coia, and G. Gettinby, "Reducing bacterial contamination in the burns dressing clinic using a novel light-based method of continuous disinfection", Oral presentation at the *15th Meeting of the International Society for Burns Injuries (ISBI)*, Istanbul, Turkey, June 21-25 2010.

H. Douglas, M. Maclean, S.J. MacGregor, J.G. Anderson, G.A. Woolsey, I. Taggart, S. Watson, J.E. Coia, K. Hamilton, B. Thakker, G. Gettinby" Early clinical experience of the use of the High Intensity Narrow Spectrum (HINS) light system for the control of *Acinetobacter* in the Burns Unit", Oral presentation at the *Birmingham National Plastic and Burns Surgery Scientific Meeting*, organized by the British Association of Plastic Reconstructive and Aesthetic Surgeons (BAPRAS), Selly Oak Hospital, Birmingham, 31st October 2009.

H. Douglas, M. Maclean, S.J. MacGregor, J.G. Anderson, G.A. Woolsey, I. Taggart, S. Watson, J.E. Coia, K. Hamilton, B. Thakker, G. Gettinby" Early clinical experience of the use of the High Intensity Narrow Spectrum (HINS) light system for the control of *Acinetobacter* in the Burns Unit", Oral presentation at the *British Burns Association 42nd Annual Meeting*, Belfast, 1 – 3 April 2009.

M. Booth, M. Maclean, S.J. MacGregor, J.G. Anderson, G.A. Woolsey, J.E. Coia, K. Hamilton and G. Gettinby, "Use of a novel light technology for environmental disinfection within an Intensive Care Unit", *Euroanaesthesia 2010*, conference of the European Society of Anaesthesiology, Helsinki, Finland, 12-15 June 2010.

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HINS-light EDS deployment in hospital environment

Benefits of HINS-Light EDS

- Continuous disinfection
- Treats the visible environment (air and surfaces)
- Effective against a wide range of pathogens
- Little/no operational requirements
- No user training
- No problems with staff/patient compliance
- No chemicals or chemical pre-treatment
- Safety advantage over UV light
- Low running costs (LED based systems)

For further information please contact:

Professor Scott J. MacGregor
- s.macgregor@eee.strath.ac.uk (0141 548 2587)

Professor John G. Anderson
- j.g.anderson@strath.ac.uk (0141 548 2649)

Dr Michelle Maclean
- michelle.maclean@eee.strath.ac.uk (0141 548 2891)

The Robertson Trust Laboratory for Electronic Sterilisation Technologies (ROLEST),
Department of Electronic & Electrical Engineering,
University of Strathclyde,
204 George Street, Glasgow, G1 1XW

Fax: 0141 552 5398 Web: www.rolest.strath.ac.uk