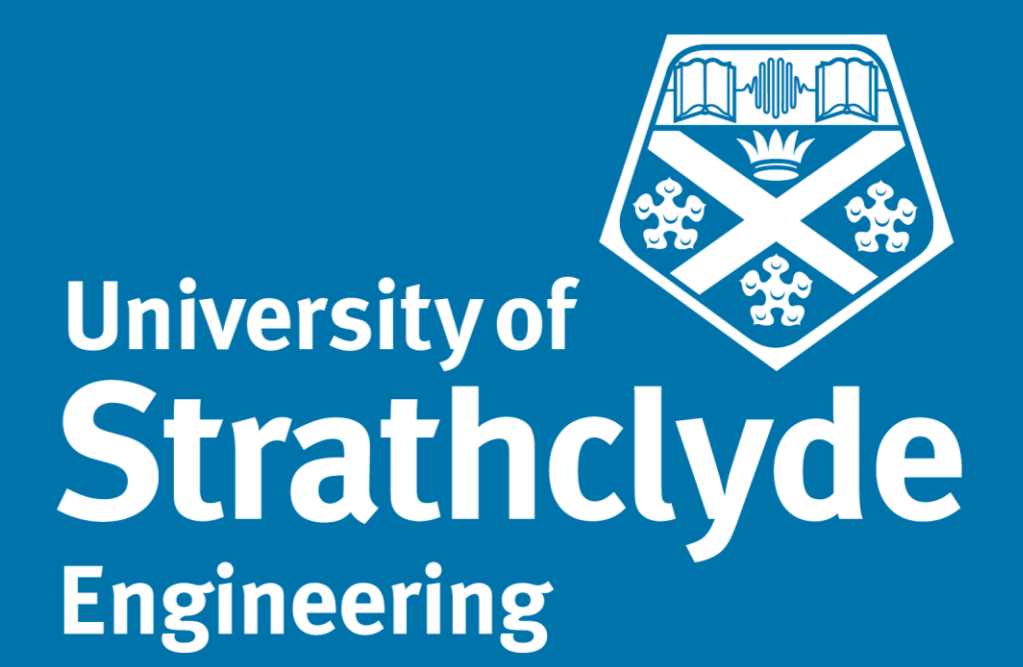


Investigating the susceptibility of laboratory-generated bacterial aerosols to antimicrobial 405nm light

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BACKGROUND AND AIMS

- Airborne transmission of infection is a major concern within the healthcare environment, with up to 20% of HAIs spread via the air.
- Traditional disinfection methods focus on surface contamination with little implemented to improve air quality.
- Ultraviolet (UV) light can be used for air disinfection, however there are operational limitations due to human safety issues.
- Visible light in the region of 405nm has wide antimicrobial efficacy and can be used as a method of 'whole room' environmental decontamination.
- This study aims to establish the dose response kinetics of airborne bacterial contamination exposed to 405 nm light and compare to UV-light.

LIGHT SOURCES

405 nm light: 405 nm LED array (PhotonStar Technologies) bonded to a heat sink and fan for thermal management with peak output close to 405 nm.

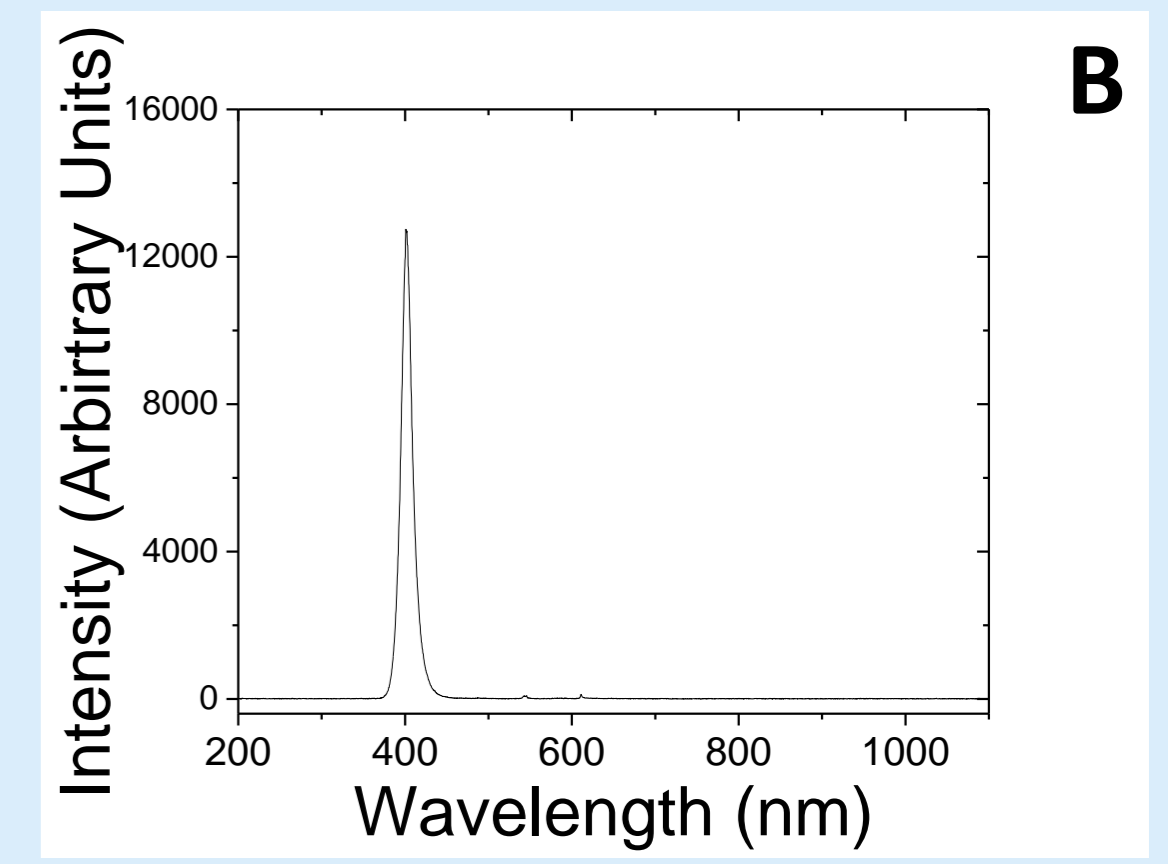


Fig 1. 405 nm LED array and (B) optical emission spectrum of 405 nm LED array.

Pulsed-UV light: Low pressure 100W xenon filled flash lamp connected to a 1kV solid-state pulsed power generator (Samtech UK) with pulse frequency of 1Hz and output energy of 20 J/pulse when pulsed at 1 pulse/second.

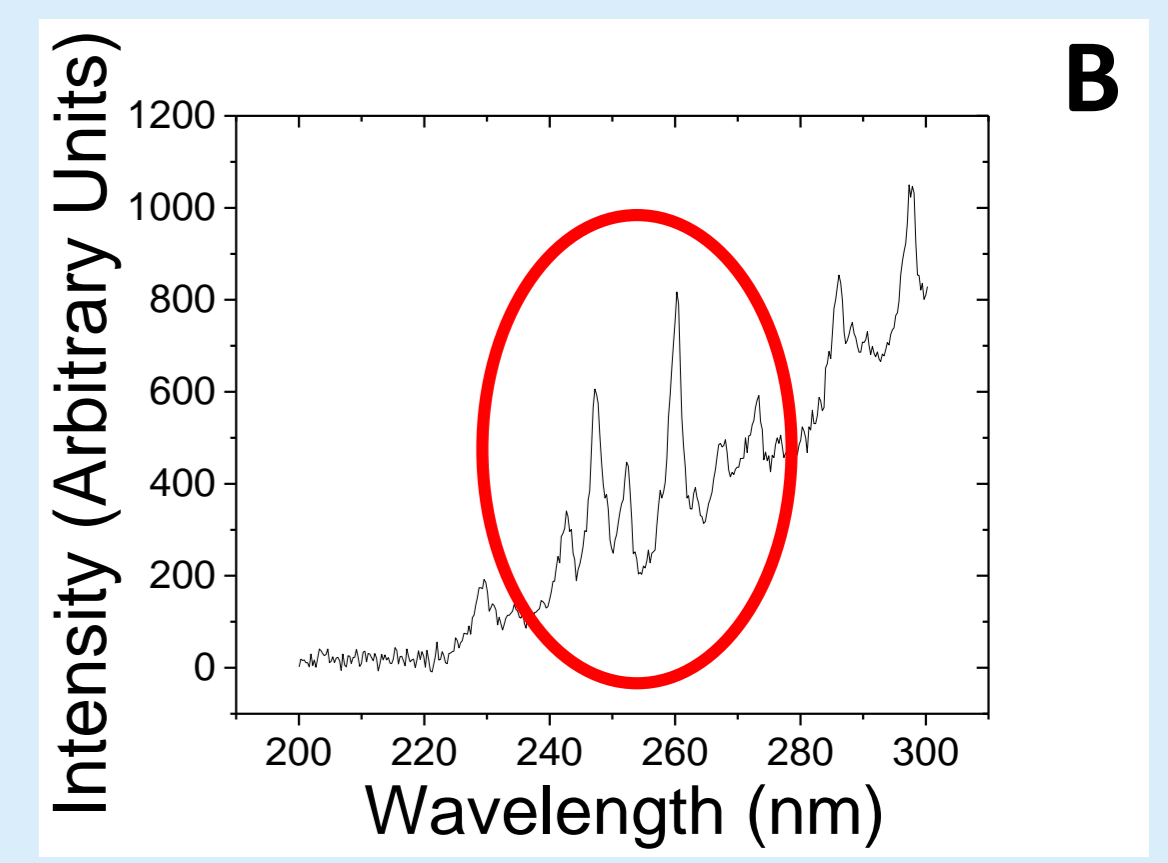


Fig 2. Xenon filled flash lamp and pulsed power generator and (B) UV-rich emission spectrum of xenon flash lamp.

SYSTEM METHODOLOGY

- S. epidermidis* was nebulised into the test chamber using a 6 Jet Collision nebuliser with 12.5 L/min flow rate.
- Aerosolized bacteria were exposed to the germicidal light source.
- Air samples were removed from the chamber using a BioSampler liquid impinger.
- The collection liquid was serially diluted, pour plated, and surviving bacteria were enumerated.

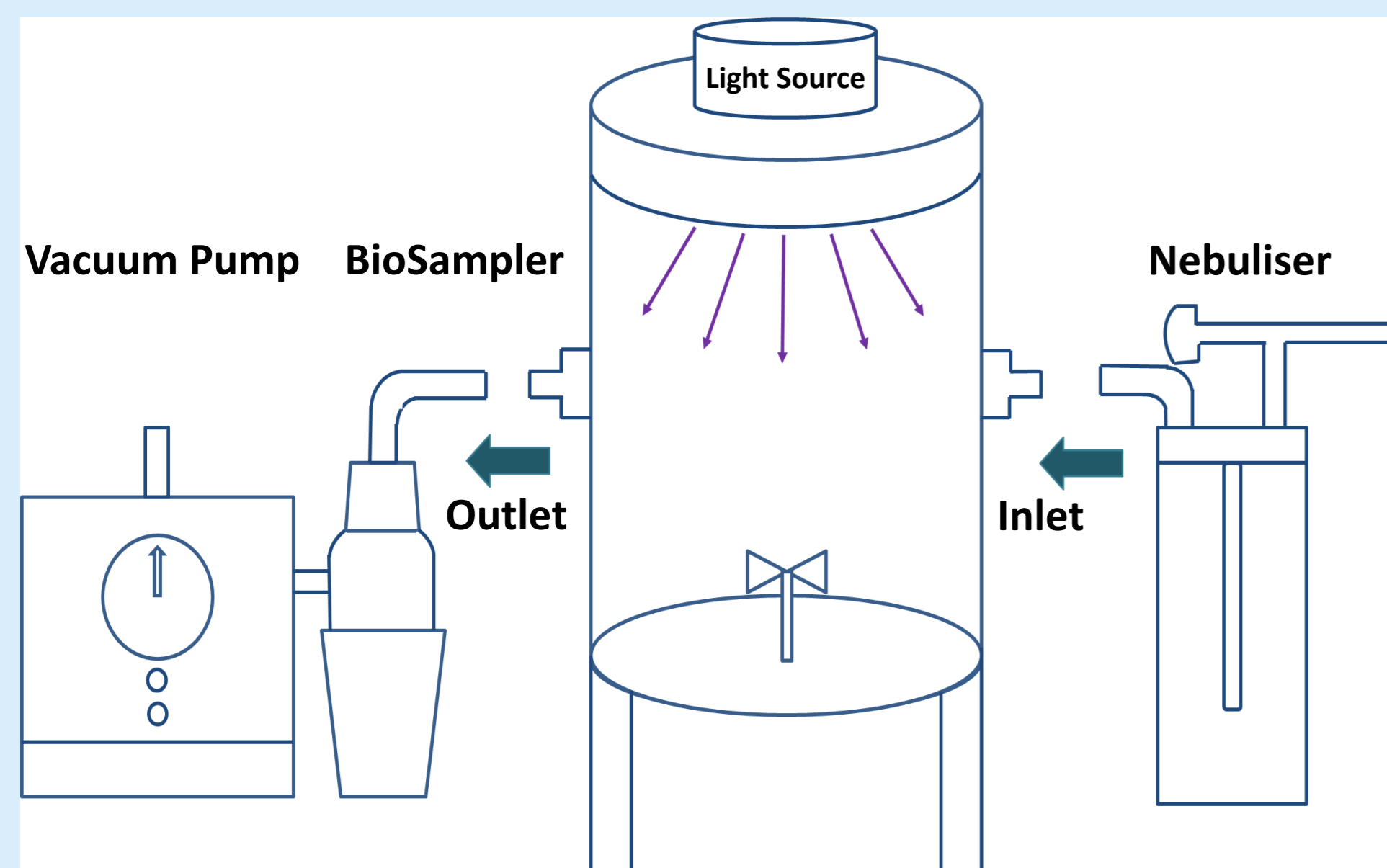


Fig 3. Experimental set up

405 nm RESULTS

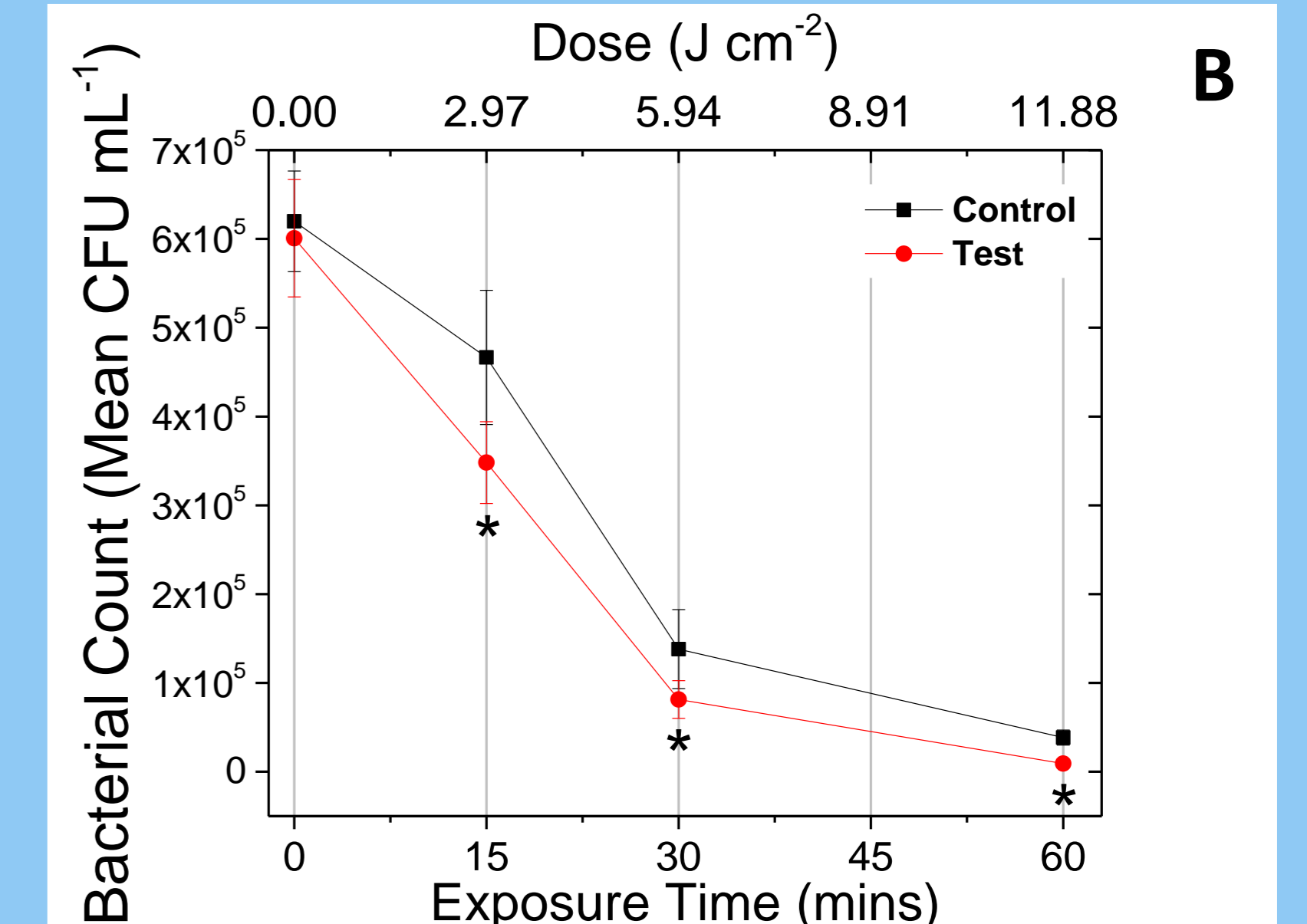
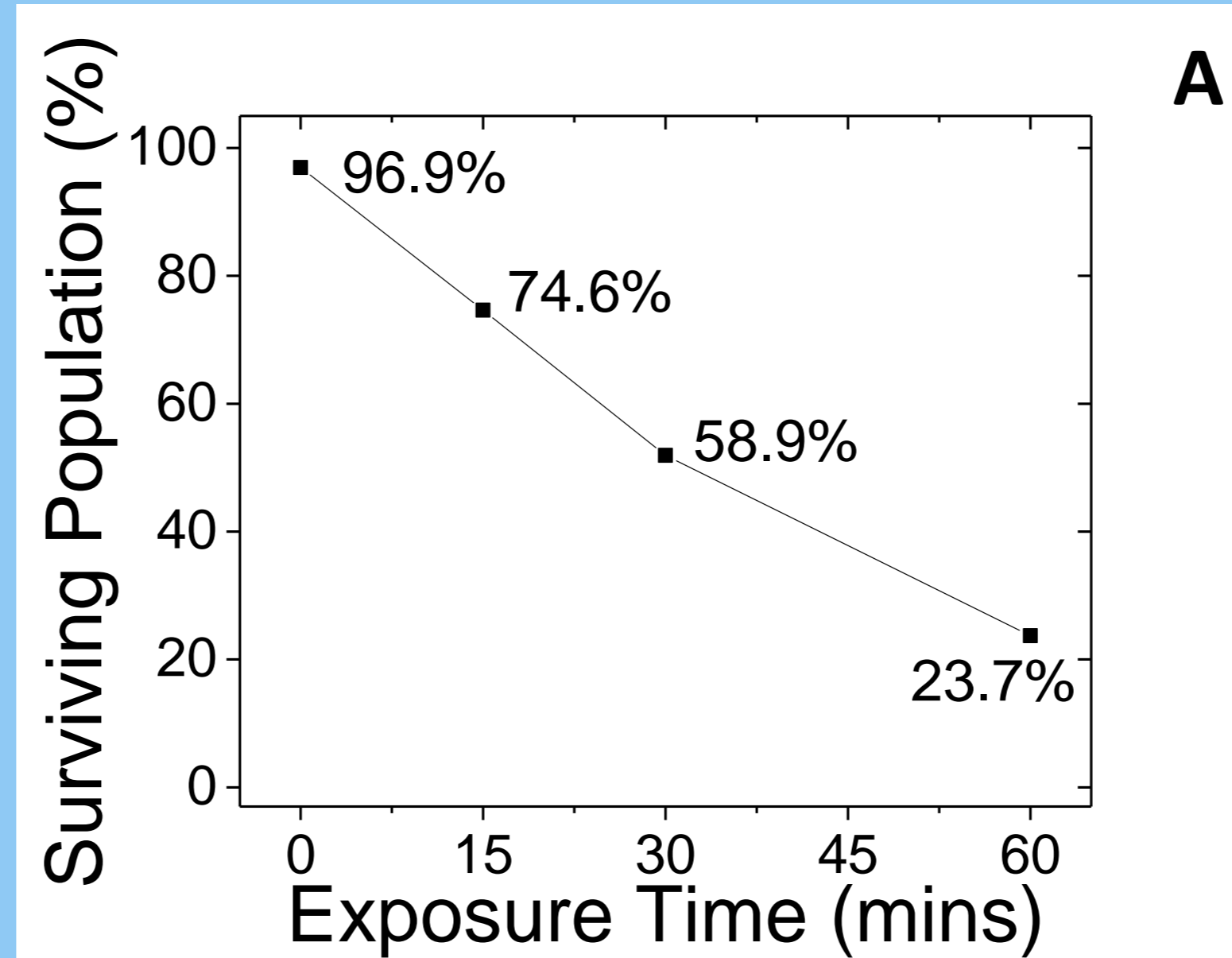


Fig 4. Percentage kill of aerosolised *S. epidermidis* to 3.3 mW/cm² low irradiance 405 nm light. (A) Percentage kill data compared to control and (B) dose-response kinetics (n≥9 ± SD).

- After a dose of 11.88 J cm⁻² (60 min treatment), a 76.3 % reduction was observed (P= 0.00002).
- Significant reduction in airborne bacteria was achieved after an initial dose of 2.97 J cm⁻² (15 min treatment) when compared to the non-exposed control sample (P= 0.00004).
- A starting aerosol population of 6.2 × 10⁵ CFU mL⁻¹ was reduced to 9.1 × 10³ CFU mL⁻¹, achieving a 1.8 log₁₀ reduction.
- Due to extended exposure times, natural decay of the aerosol was observed, however this was significantly less than with light treatment.

CONCLUSIONS

- Aerosols of *S. epidermidis* were susceptible to low dose 405 nm light, however, improvements in the test system are required to reduce the impact of natural decay over extended exposures.
- Pulsed-UV light is highly efficient for decontamination of airborne bacteria.
- Although less germicidally efficient, the benefits of 405 nm light provide increased safety for human exposure and whole room decontamination.

FUTURE WORK

- Increasing the irradiance of the 405 nm light sources to establish the potential for quicker inactivation.
- Investigation of aerosol dynamics to improve suspension inside the test chamber.
- Continuous-UV exposure of aerosolised *S. epidermidis* to further compare germicidal efficacy of light-based decontamination technologies.

PULSED-UV RESULTS

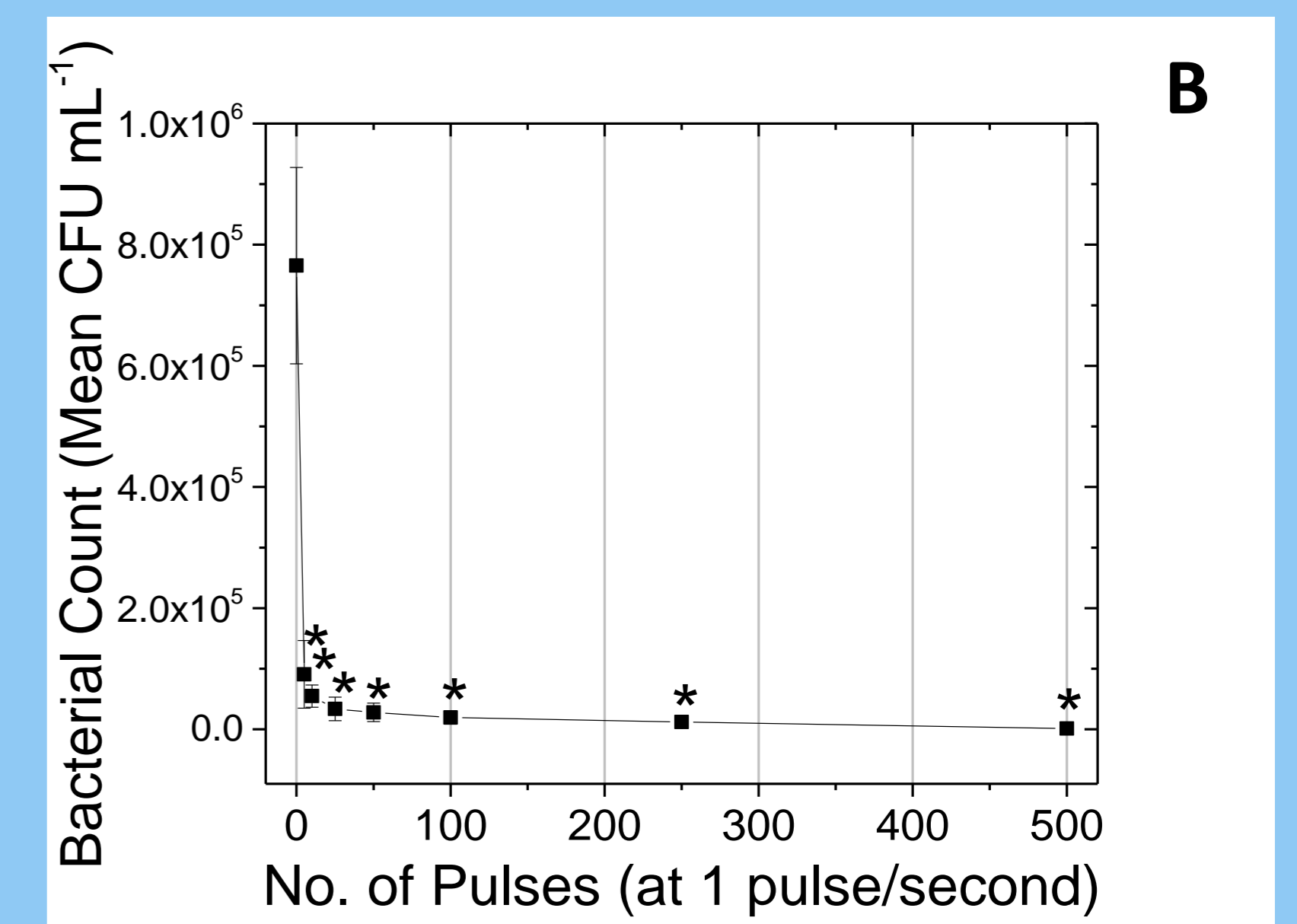
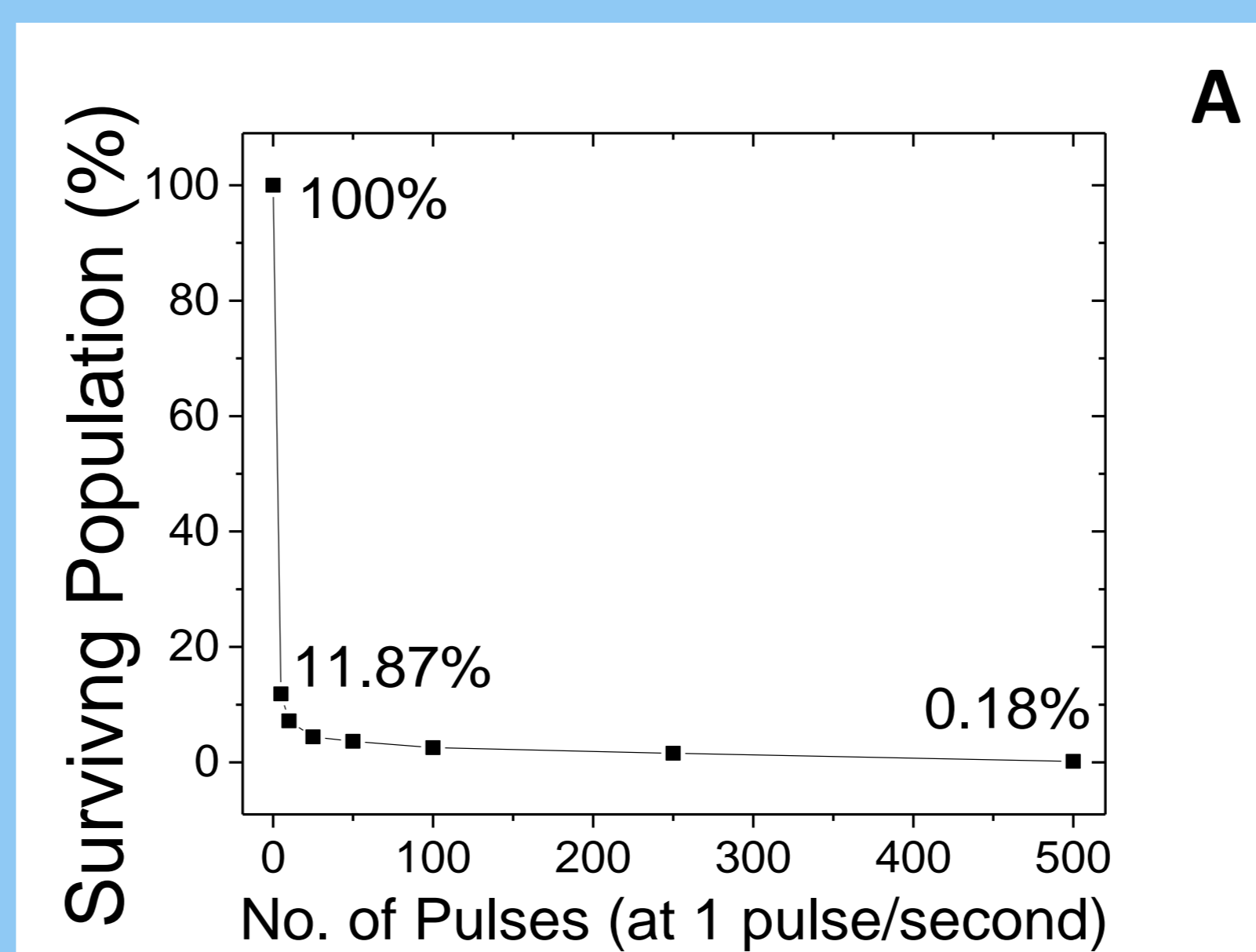


Fig 5. Investigating the susceptibility of aerosolised *S. epidermidis* to pulsed UV light. (A) Stored electrical energy was transferred from a solid state power source to a low pressure xenon flash-lamp discharging short pulses of UV light at 1 pulse/second. (B) percentage surviving (n≥9 ± SD).

- Significant reduction in airborne *S. epidermidis* was achieved after an initial dose of 5 pulses at 1 pulse/second (P=0.0000012). At this dose (5 second treatment) an 88.13% reduction was observed.
- Tailing began to be observed after 25 pulses, however the total bacterial count remaining was less than 5%.
- After 500 pulses at 1 pulse/second, a 2.8 log₁₀ reduction was achieved, with less than 1% of the starting population surviving at this dose (p=0.0000058).