Thursday, December 18, 2025

Poster abstract submission

Approval Status Not Started

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Poster title

Sub-inhibitory Surfactant Combinations Drive Mechanistic Adaptation and Preclinical AMR Risk in wild-type Escherichia coli

Poster abstract

Non-antibiotic antimicrobials (NAAMs), such as the cationic surfactant benzalkonium chloride (BAC) and the anionic surfactant sodium lauryl sulfate (SLS), are common in disinfectants and personal care products and are often used together. Although they show synergistic bactericidal effects at lethal concentrations, their persistence at sub-inhibitory levels in healthcare, domestic, and environmental settings raises concerns about unintended selection of antimicrobial resistance (AMR). Despite this, the mechanistic and preclinical AMR risks associated with exposure to these combined surfactants remain poorly understood. In this study, wild-type Escherichia coli underwent 30 days of adaptive laboratory evolution under gradually increasing sub-minimum inhibitory concentrations (sub-MICs) of BAC + SLS (0.625–2.5 mg/L). Tolerance was assessed using time- kill kinetics, killing rates, and survival dynamics. Cellular adaptations were evaluated by examining oxidative membrane damage, intracellular ATP depletion, efflux pump activity (ethidium bromide extrusion), and biofilm formation. Additionally, antibiotic cross- resistance was analyzed against six clinically relevant antibiotics, and resistance evolution velocity, multidrug resistance (MDR) indices, and clinical risk profiling were assessed. Prolonged exposure to sub-MIC levels of BAC + SLS resulted in significant, dose-dependent tolerance, evidenced by reductions in bactericidal killing rates of up to 90% and a 16-fold increase in survival during high- dose challenges. Adapted populations displayed convergent physiological remodelling, including enhanced efflux pump activity (up to 2.47-fold), increased oxidative stress, reduced ATP synthesis, and marked biofilm formation (up to 8.7-fold). These mechanistic alterations were accompanied by rapid development of antibiotic cross-resistance, particularly to β-lactams and trimethoprim-sulfamethoxazole, with minimum inhibitory concentration (MIC) increases reaching 256–2048-fold, thereby elevating MDR and clinical resistance risk indices. Overall, these findings indicate that mixed surfactant biocides can be significant, preclinically relevant drivers of AMR through shared adaptive mechanisms. This research underscores the necessity of incorporating non- antibiotic antimicrobial combinations into resistance risk assessments, disinfectant development, and antimicrobial stewardship strategies.

Research topic

Microbiology