LOCALIZING CHEMICAL AND BIOLOGICAL THREAT DETECTION

Risk Exposure And Mitigation Of Potentially Airborne Infectious Diseases On The Usns Mercy, A Navy Hospital Ship

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Our research characterizes the spread and clearance of a potentially infectious aerosol on a hospital ship, the USNS Mercy, and informs generalized recommendations to reduce risk and provide better outcomes to patients and staff.

Hospital environments are particularly vulnerable to airborne infectious diseases – including COVID-19, influenza, and tuberculosis – due to the concentration of contagious patients, a large staff providing care to multiple patients, and a vulnerable population (e.g., immunocompromised patients). At any given time, one in 31 hospitalized patients has at least one healthcare-associated infection (HAI), leading to over 680,000 infections and nearly 100,000 deaths in the United States every year. However, many HAIs are preventable through best practices, such as ventilation standards set by ANSI/ASHRAE/ASHE.

The USNS Mercy is a 1,000-bed hospital ship that provides afloat, surgical medical facilities to the U.S. military, as well as services to support disaster relief and humanitarian operations worldwide. In early 2020, MERCY and its sister ship, the USNS Comfort, were deployed to Los Angeles and New York City to provide relief in response to the COVID-19 pandemic, highlighting the risk of airborne infectious disease to U.S. sailors. Our research captures a snapshot of the current risk exposure for patients and staff on MERCY and evaluates several risk mitigation factors, such as portable HEPA filter systems used in various configurations to augment the existing HVAC system and the preferential placement of patients within the wards.

A custom-built aerosol generator was used to release fluorescent tracer particles in various spaces of interest across the ship, including wards, casualty reception, ICUs, and isolation wards. The aerosol data was used to calculate an effective air change rate for empirically observed particles, as well as cumulative and relative exposure at each sensor location. Additionally, our methodology represents a standardized way to study and compare the spread and clearance of aerosols throughout any indoor environment.

Preliminary results demonstrate that several spaces on MERCY do not meet hospital ventilation standards for minimum air changes per hour. However, these standards can be achieved by placing a number of portable HEPA filters throughout the space. HEPA filter configurations biased towards ward entrances and recirculation vents can be utilized to protect adjacent wards, although this comes at the expense of higher cumulative exposure within the ward of release. A similar effect is observed by selectively placing patients near exhaust vents at the back of the wards, away from entrances and recirculation vents. Physical proximity and barriers are also a factor; less aerosol spread was observed out of the lowest, most peripheral wards and bulkheads were effective in limiting the spread to sections of the ship fore and aft of the release.

Our research informs guidelines and recommendations to reduce risk due to airborne infectious diseases in a shipboard setting. Additionally, the test methodology is an effective way to examine aerosol metrics – including effective air change rate, cumulative exposure, and relative exposure – of real-world particles at relevant threat sizes in a complex indoor environment.

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