Design and Testing of Hospital Ventilation System Using Bioaerosols

Connor Purcell, Garrett B. Shaw, Vedanta Dasu
Dr. Maria King, Dr. Gerald Riskowski

BIOLOGICAL & AGRICULTURAL ENGINEERING
TEXAS A&M UNIVERSITY

Problem Statement

Maintaining a clean hospital room environment is a challenging task. Airborne pathogens present a particular concern due to their rapid transmission in the hospital environment, along with the increased potential to for bacteria to acquire antibiotic resistance. The current air exchange rate requirement for hospital rooms is 6 room volumes per hour, which causes significant turbulence resulting in increased residence time of bacteria in the room.

Design Objectives

Develop and model three ventilation designs with CFD models of airflow velocity to improve removal of bioaerosols in a BSL-1 ¾ scale hospital chamber. Develop a bioaerosol testing procedure to ensure viability of cells throughout trial. Investigate the the effect of turbulence on the antibiotic resistivity of cells. Determine the effects of an air curtain on air turbulence and microbial levels.

Constraints

- **Time**: Time for testing in the chamber was limited to ensure survivability of the bacteria.
- **Equipment**: ¾ scale model room must be used with existing dispersion/collection equipment and HVAC system

Design Approach

- Design three ventilation configurations to minimize air turbulence
- Simulate airflow for configurations using Solidworks
- Modify the ¾ scale chamber to the design specifications for each configuration
- Disperse and collect nonpathogenic *E coli.* in ¾ hospital room
- Plate collected samples to determine total bacterial counts (TBC) and antibiotic-resistance before and after dispersal
- Analyze results and make modifications to room as necessary

Solidworks Model of Airflow

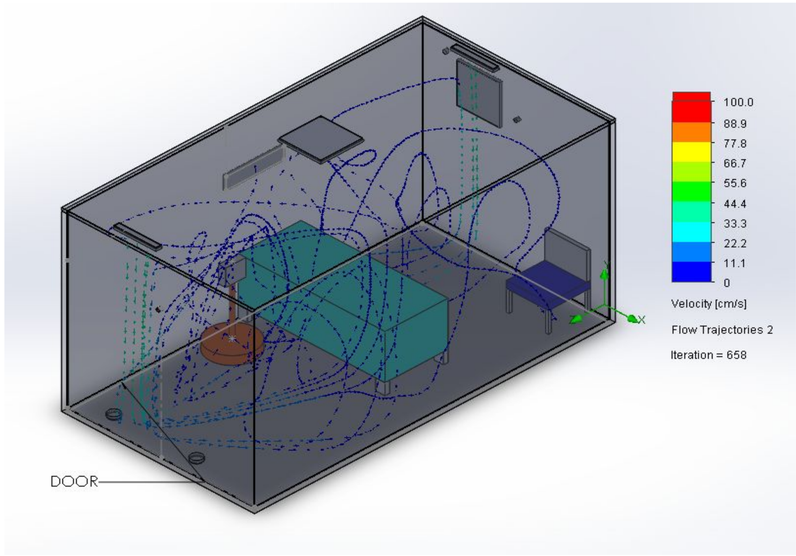

Figure 1. Final Design Isometric View

Bioaerosol Testing Procedure

- Prepare E.coli solution at 10^8 cells/mL
- Disperse using a 24-jet Collison Nebulizer
- Collect using twelve 47 mm polycarbonate filters, 0.4 µm pore size
- Collection taken when HVAC system is running/stopped
- Plate all samples and determine total bacterial counts
- Perform Kirby Bauer test to quantify antibiotic resistance between bacteria before and after dispersion/collection

Economic Analysis

Component/Part	# of Units	Cost
Petri Dish	120+	$40
Agar	3 L	$10-20
Growth Media (LB)	3 L	$10-20
E. coli MG1655	5 mL	TBD
Millipore Filters	110	$50-60
90° PVC fitting	2	$15

Results

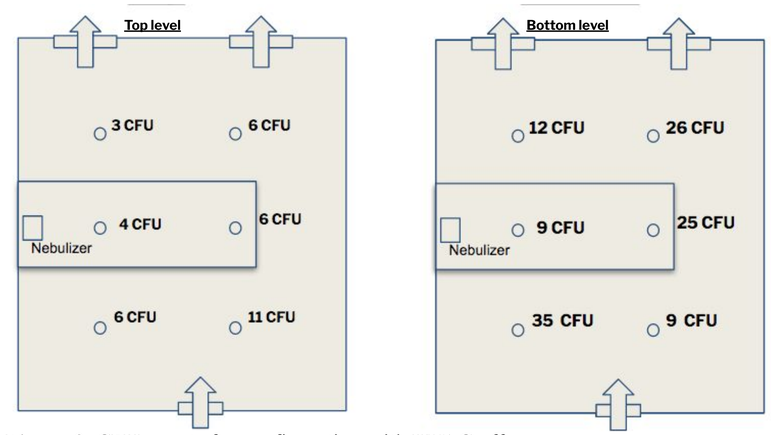

Figure 2. CFU counts for configuration with HVAC off

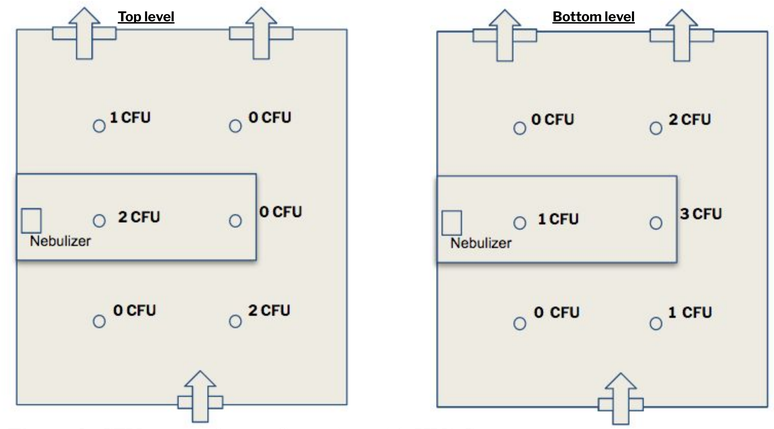

Figure 3. CFU counts for configuration with HVAC on

Discussion

- The HVAC-on trial resulted in significantly lower levels of TBC than HVAC-off trial, indicating efficient removal of nebulized *E. coli* with the proposed ventilation system
- Higher levels of *E. coli* was collected in the bottom level of collectors, suggesting settling of nebulized particles
- Kirby Bauer results indicate no significant difference in antibiotic-resistance levels before and after *E coli* collection
- Our results show that increased *E. coli* concentration in nebulizer feed liquid (>10^{11} CFU/mL) during HVAC-on mode is needed to improve collection and TBC.