EXTENDED ABSTRACT
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Preventing TB in the Workplace: Principles and Practices for Controlling Transmission

ABILITY OF A FAN-POWERED UVGI DISINFECTION UNIT TO INACTIVATE SELECTED AIRBORNE BACTERIA

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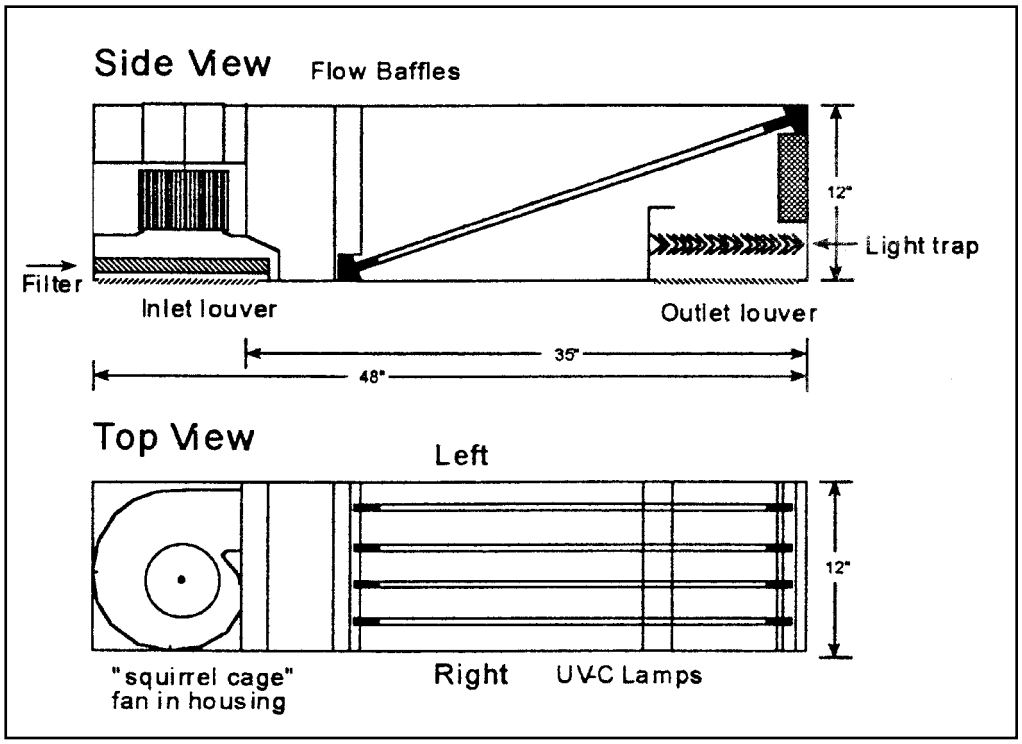
Background: Ultraviolet germicidal irradiation (UVGI) has been shown by other researchers to inactivate a variety of airborne microbes, including tubercle bacilli, and to help prevent the airborne transmission of disease. To date, the most common use of UVGI has been in upper air irradiation, which relies on room air currents to bring airborne microbes into a zone of irradiation. The low radiation intensity in the upper air and the risk of human exposure to UVGI have had a negative impact on the use of upper air irradiation for infection control.

Objectives/Methods: This study was designed to indicate the ability of a fan-powered UVGI unit to inactivate airborne bacteria. The unit contained four lamps and was designed to inactivate airborne microbes while minimizing human exposure to UVGI (Fig 1). As a preliminary step to tests directly using mycobacteria *(M. tuberculosis H37Ra* and *M. bovis BCG* strain), the unit was tested against bioaerosols of *Escherichia coli, Pseudomonas fluorescens, Serratia marcescens,* and *Micrococcus luteus*. The test bacteria were aerosolized into the NIOSH bioaerosol chamber and passed through the disinfection unit in a series of experiments.

Bioaerosols were collected and enumerated using AGI-30 impingers (Ace Glass, Inc.) and Andersen six-stage (viable) microbial particle sizing samplers.

Figure 1:



Each test bacterium was evaluated in an experiment consisting of at least eight runs. The first two runs were replicate controls, in which the UVGI lamps were off and the dust filter was removed. These control runs were used to characterize the expected decrease in the culturable bioaerosol concentration by passage through the UVGI unit with no effects from irradiation or the dust filter. The control runs were followed by six replicate test runs with the UVGI lamps on and the dust filter in

place. Percent survivals were calculated using data from these six test runs by equations (1) and (2):

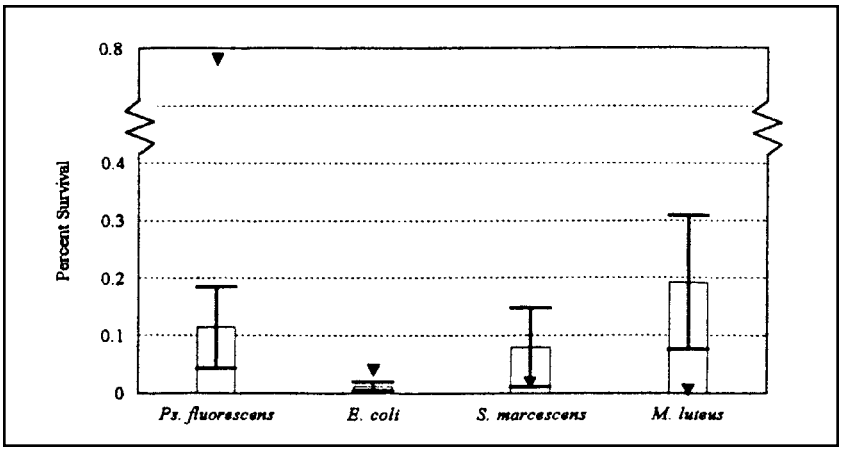
$$(1)\ \text{Ratio} = \frac{\text{Outlet}_{\text{control}}}{\text{Inlet}_{\text{control}}} \qquad (2)\ \text{Survival} = \frac{\text{Outlet}_{\text{test}}}{\text{Ratio}*\text{Inlet}_{\text{test}}}$$

where $\text{Outlet}_{\text{control}}$ is the average culturable bioaerosol concentration at the outlet of the unit from the control run in units of CFU per cubic meter of air sampled, $\text{Inlet}_{\text{control}}$ is the concentration at the inlet of the unit during the control runs, $\text{Outlet}_{\text{test}}$ is the average concentration at the outlet of the unit from the test runs, and $\text{Inlet}_{\text{test}}$ is the concentration at the inlet of the unit during the test runs.

The ratio calculated in equation (1) is the proportion of bacteria expected to remain aerosolized and culturable after passage through the UVGI unit under control conditions. The product of Ratio and $\text{Inlet}_{\text{test}}$ in the denominator of equation (2) is the expected concentration of bacteria at the outlet of the unit. The percent survival calculated in equation (2) is the quotient of the actual concentration of culturable bacteria collected at the outlet by the expected concentration of culturable bacteria at the outlet.

Results: Based on the concentration of bioaerosol collected at the inlet and outlet of the test unit, we estimated that more than 99% of the bacteria irradiated within the test unit were inactivated (Fig 2). The survival rate was calculated as the ratio of collected bacteria after UVGI exposure to the collection with no UVGI exposure.

Figure 2: Survival rates of the test bacteria after irradiation in the UVGI unit



Conclusions: At the measured flow rate of 275 cfm, the disinfection unit may add up to 15 equivalent air changes per hour to the mechanical ventilation of a 10' x 12' x 9' TB isolation room. This unit may provide an economical way to supplement existing infection control measures in indoor environments by increasing existing dilution ventilation rates.

Ventilation rates above the required 6 ACH can provide a substantial reduction in the time required to remove an aerosolized pathogen. In this study, the action of the UVGI unit on the test bacteria was shown to inactivate or remove nearly all of the bacteria from an air volume. From this finding, we can infer that the passage of one room air volume through the unit has the same effect on the number of pathogenic bacteria remaining in the room as one mechanical air change would. The UVGI unit tested is capable of adding 15 ACH to the 6 mechanical ACH in a standard sized isolation room (120ft^2) (AIACAH, 1993) with a nine-foot ceiling. The time required for 90% assurance that an aerosolized respirable pathogen passes either through the ventilation system or through the UVGI unit is thereby decreased from 23 minutes to 6.6 minutes, reducing the time the pathogen was probably aerosolized by 71% and reducing the risk of infection.