

Upper Room Ultraviolet Germicidal Irradiation (UVGI) Air Disinfection On An MDR-TB Ward In Sub-Saharan Africa – Effects Of Humidity

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Rationale: Transmission of multi and extensively drug resistant (MDR and XDR) TB in congregate settings threatens global TB control. Recommended engineering interventions to reduce transmission include high rates of natural/mechanical ventilation and use of upper room UVGI with good air mixing, but with very little direct evidence of efficacy. We sought to directly measure the efficacy of upper room UVGI in reducing TB transmission on an actual MDR-TB ward with low and high humidity. High humidity purportedly negatively affects UVGI efficacy.

Methods: For each 2-3 month study, a series of 6 consenting MDR/XDR patients simultaneously occupied the Airborne Infections Research facility ward at the Mpumalanga Provincial MDR Referral Hospital in Witbank, South Africa. Patients were selected for features associated with increased transmissibility: smear (+) sputum, coughing, lung cavitation, and recent initiation of standardized treatment, and remained on the ward 2 weeks before being replaced. Patient rooms, hallways, and a common area were equipped with UVGI fixtures producing high levels of upper room UVGI with safe exposure levels in the lower, occupied portion of the room. Slow paddle fans assured good air mixing in the rooms. A mechanical ventilation system exhausted all ward air to two identical exposure chambers each containing 90 tuberculin skin test (TST) negative, pathogen-free laboratory guinea pigs. Guinea pigs are highly susceptible to TB and serve as living sentinel air samplers for infectious airborne TB droplet nuclei. After a baseline TST, monthly TST conversions represented the fraction of infected animals in each chamber. Experimental animals only breathed UV irradiated ward air on even days whereas control animals only breathed unirradiated ward air on odd days. Low (55 – 65%) and high (70 – 80%) humidity were achieved using a humidifier. Upper room UVGI efficacy was determined by comparing the proportion of infected animals in each chamber and using survival analysis.

Results: Under low humidity, 0 experimental guinea pigs versus 9 control guinea pigs became infected (100% efficacy for UV). In a second low humidity study, 15 experimental guinea pigs versus 48 control guinea pigs became infected (69% efficacy for UV). Combined survival analysis for differences in infections between the 2 arms was highly significant ($p < 0.0005$) with a hazard ratio of 4.9 (95% CI 2.8-8.6) for infection breathing unirradiated air. A third study with high humidity is currently in progress.

Conclusions: Upper room UVGI with low humidity very effectively reduces airborne TB transmission under real world conditions in Africa.

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