THE UNIVERSITY OF ARIZONA
Mel and Enid Zuckerman College of Public Health

Division of Community, Environment and Policy

Roy P Drachman Hall
1295 N Martin Avenue
P.O. Box 245210
Tucson, AZ 85724-5210
Tel: (520) 626-3589
Fax: (520) 626-8009

Hospital Field Study of T1 Air Disinfector Recirculator Efficacy Against Viral Tracers

Prepared for:
Brent Lloyd and David Kirschman
Aerobiotix, Inc.
454 Alexandersville Rd.
Miamisburg, OH 45429 USA

Prepared by:
Marc Verhougstraete and Kelly Reynolds
The University of Arizona
Mel and Enid Zuckerman College of Public Health
Environment, Exposure Science and Risk Assessment Center

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EXECUTIVE SUMMARY

Research has shown that microbial pathogens are commonly transmitted through the aerosol route to surfaces, equipment, and hands in the clinical setting. This project aimed to quantitate the efficacy of the Aerobiotix T1 Air Disinfector Recirculator against viruses in real-time hospital settings.

Two hospital rooms were used during this study: a pediatric intensive care unit (PICU) patient room and a neonatal intensive care unit (NICU) procedure room. The air in each room was seeded with coliphage ΦX-174. Air samples were collected to assess the efficacy of the hospital HVAC system and the Aerobiotix T1 unit. Samples were processed at The University of Arizona's Environmental, Exposure Science and Risk Assessment Center (ESRAC) laboratory following USEPA method 1601.

In total, 212 samples were collected during this project: 144 from the PICU patient room and 68 from the NICU procedure room. In the PICU patient room, the average reduction of seeded coliphage concentrations under the natural HVAC conditions (2.46 log) was not significantly different ($p=0.225$) from the Aerobiotix T1 removal rates (2.92 logs). In the NICU procedure room, the average reduction of seeded coliphage concentrations under the natural HVAC conditions (1.76 log) was not significantly different ($p=0.980$) from the Aerobiotix T1 removal rates (1.77 logs).

The Aerobiotix T1 unit provided improved airborne viral concentration reduction by about 0.5 logs compared to hospital HVAC in the PICU patient room. In the NICU procedure room, no measureable differences were detected between the Aerobiotix T1 and the natural HVAC system; likely a factor of the extreme air exchange rate (37.5 exchanges $hour^{-1}$). Future research should focus on additional investigations in the PICU patient room that incorporates fomite and air testing. Including fomite testing may highlight the Aerobiotix T1 capabilities to reduce the amount of aerosolized microbes that rapidly settle on surfaces.

INTRODUCTION

Infections acquired in hospitals are a major problem worldwide. In the United States alone, there are an estimated 35 million admissions to acute care facilities each year. Of these, 1.7 million of these patients are affected by a secondary infection. Approximately 100,000 secondary infections result in death [1]. The risk of secondary infection increases with the time spent in the hospital [2].

Research has shown that microbial pathogens are commonly transmitted through the aerosol route to surfaces, equipment, and hands in the clinical setting. Our data, and that of others, have shown that methicillin resistant *Staphylococcus aureus* and other nosocomial pathogens have been isolated from surfaces and the air both during and in the absence of documented cases, despite extensive cleaning and disinfecting protocols. This data suggests that a passive air disinfecting system could reduce pathogen prevalence and the risk of patient exposures.

The primary objective of this project was to quantitate the efficacy of the Aerobiotix T1 Air Disinfector Recirculator against viruses in real-time hospital settings using viral tracers.

METHODS

Room selection

Two rooms located in a hospital (Tucson, Arizona, USA) were enlisted during this study: a pediatric intensive care unit (PICU) patient room (Figure 1) and a neonatal intensive care unit (NICU) procedure room (Figure 2). Each room was unoccupied at the time of sampling.

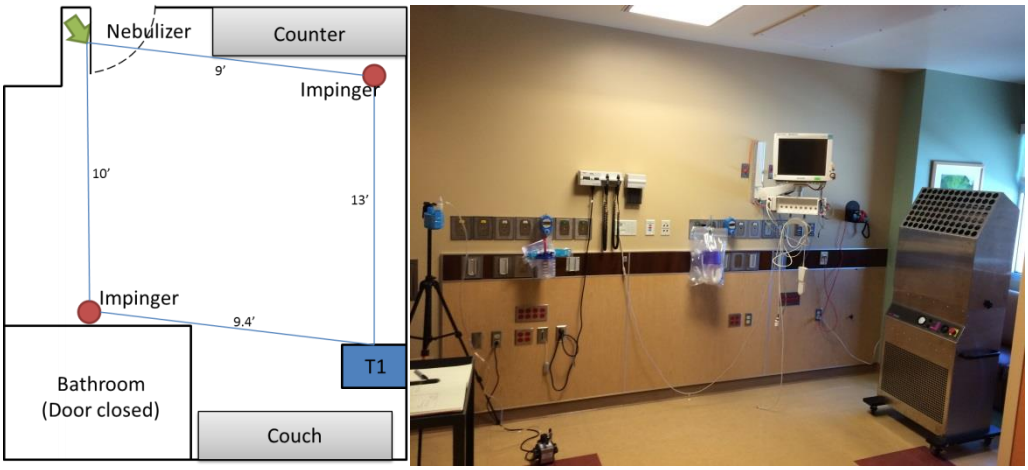

Figure 1. Pediatric Intensive Care Unit Patient Room. Schematic not drawn to scale

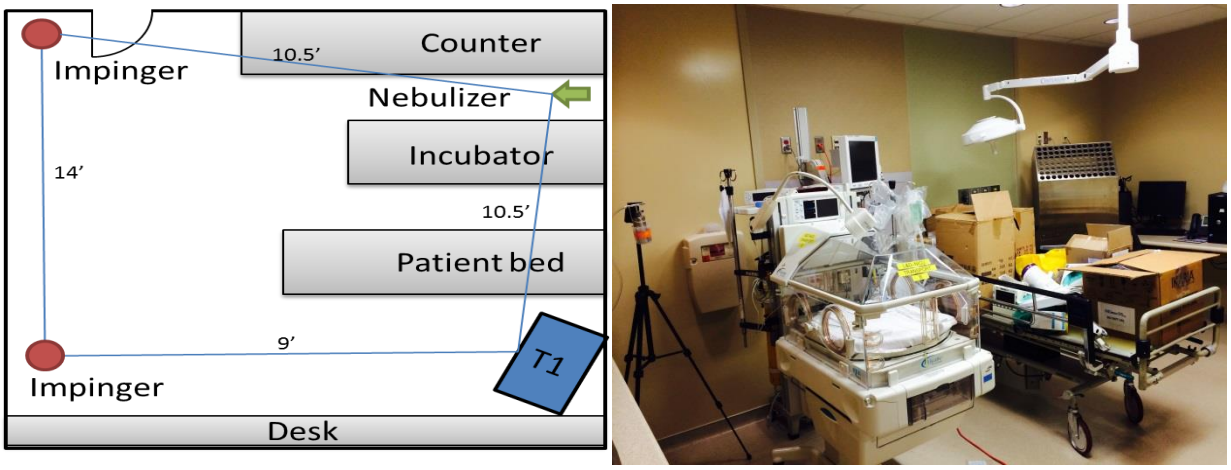

Figure 2. Neonatal Intensive Care Unit Procedure Room. Schematic not drawn to scale

Air Seeding

To seed the sampling room air, 20 ml of coliphage ΦX-174 stock (concentration: 2.08 x 10^8 PFU/100ml) was added to a sterile nebulizer. The nebulizer was placed 1.52m above the floor and attached to a pump with a rate of 12.7 L/min. Seeding events lasted for 15 minutes in PICU patient room and 20 minutes in the NICU procedure room.

Hospital Room Measurements

Air temperature and percent relative humidity were recorded at the beginning and end of each sampling event using a digital hygrometer/thermometer (Fischer Scientific Certified Traceable, product number 11-661-8).

Sterile glass impingers (SKC Midget Impinger with Standard Nozzle, product number 225-36-1) were filled with 10ml of sterile phosphate buffered solution (PBS) and connected to air sampling pumps using sterile rubber tubing. Air sampling pumps (Allegro Industries D2 Moldlite Sampling Pump, product number 9800-88) were calibrated daily to 12.5 L/min (± 5%) prior to collecting air samples. Impingers were placed 1.52m above the floor. All air samples were collected for 10 minute exposures. After 10 minutes of exposure, impingers were sealed with parafilm and placed on ice in a cooler for transportation to The University of Arizona's Environmental, Exposure Science and Risk Assessment Center (ESRAC) laboratory for processing.

Two air-sampling approaches were used during the project. In the PICU patient room, the air was seeded with coliphage (T-0) before measuring the natural removal of the hospital HVAC system and (T-30) before challenging the Aerobiotix T1 Air Disinfector Recirculator, as described in Table 1. In the NICU procedure room, the air was seeded with coliphage at T-0 only, as described in Table 2.

Table 1. Time point details for experiments performed in a pediatric intensive care unit patient room

TIME	Minutes	STEP
Seed	15 minutes	Seed air with phage
T-0	10 minutes	Sample air
T-10	10 minutes	No intervention (natural HVAC movement only)
T-20	10 minutes	Sample air
T-30	15 minutes	Seed air with phage
T-45	10 minutes	Sample air
T-55	10 minutes	Intervention (Aerobiotix)
T-65	10 minutes	Sample air

Table 2. Time point details for experiments performed in a neonatal intensive care unit procedure room

TIME	Minutes	STEP
Seed	20 minutes	Seed air with phage
T-0	10 minutes	Sample air
T-10	10 minutes	No intervention (natural HVAC movement only)
T-20	10 minutes	Sample air
T-30	10 minutes	Intervention (Aerobiotix)
T-40	10 minutes	Sample air

PBS from the impingers was aseptically poured into a sterile 50ml conical tube. Impingers were rinsed with 10ml of sterile PBS and the rinsate was added to the same 50ml tube. Samples were diluted with sterile PBS. Double agar layers were utilized to detect a coliphage strain on selected hosts (*E. coli* CN-13; ATCC 700609) following EPA methods 1601 [3]. Clearings in the host lawn were counted and reported as plaque forming units (PFU) m^{-1}. ΦX-174 coliphage was used as a positive control for verification of media integrity. Sterile reagent water was used as a negative control for verification of method integrity [4].

RESULTS

In total, 212 samples were collected as part of the Aerobiotix T1 challenge experiment. In the pediatric intensive care unit (PICU) patient room, 144 samples were collected over 3 dates. In the neonatal intensive care unit (NICU) procedure room, 68 samples were collected over 3 dates. However, samples collected on 8/31/2014 in the NICU were not included during statistical analysis due to omission of the HVAC control. Thus, statistical analyses on the NICU samples were performed on 48 samples from 2 dates.

The results from a PICU patient room indicate that on average the natural air circulation from the hospital HVAC system provides a 2.46 log reduction of seeded coliphage concentrations in the air (Figure 3). When the Aerobiotix T1 unit was utilized as a treatment in the same environment, on average a 2.92 log reduction of seeded coliphage concentrations in the air was observed.

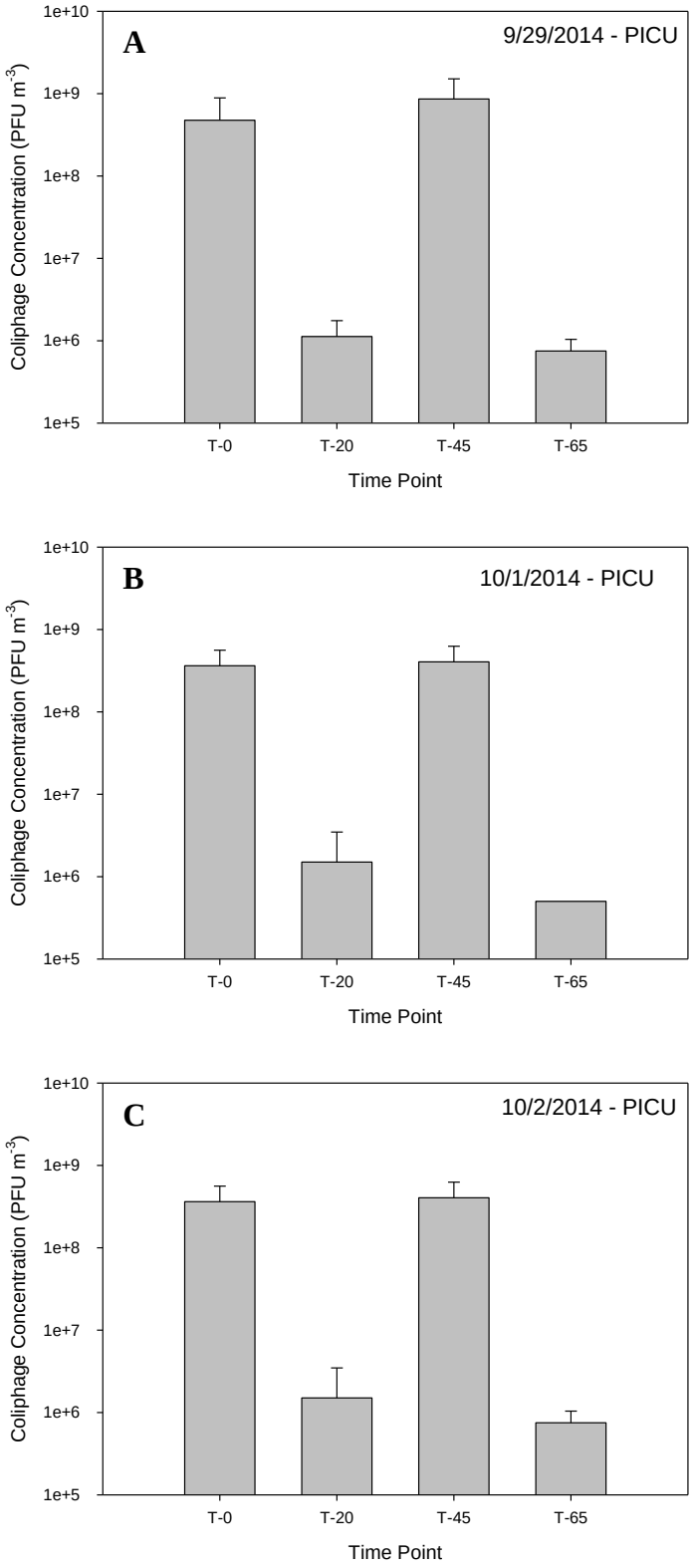

Figure 3. Coliphage results following air seeding and treatments in a pediatric intensive care unit patient room on A) September 29, B) October 1, and C) October 2. Time points defined in Table 1. Detection limit equal to $1.0X10^5$ and represented as the minimum y-axis value shown in the figure.

The concentrations of coliphage measured after the HVAC control and after treatment of Aerobiotix T1 unit in the PICU were not statistically different (p = 0.225).

In the NICU procedure room, average reductions of seeded coliphage concentrations in the air were 1.76 and 1.77 logs under the natural HVAC conditions and following the treatment with the Aerobiotix T1 unit, respectively. The concentrations of coliphage measured after the HVAC control and after treatment of Aerobiotix T1 unit in the NICU were not statistically different (p = 0.980). Coliphage results in the neonatal intensive care unit procedure room following air seeding and treatments are illustrated in Figure 4.

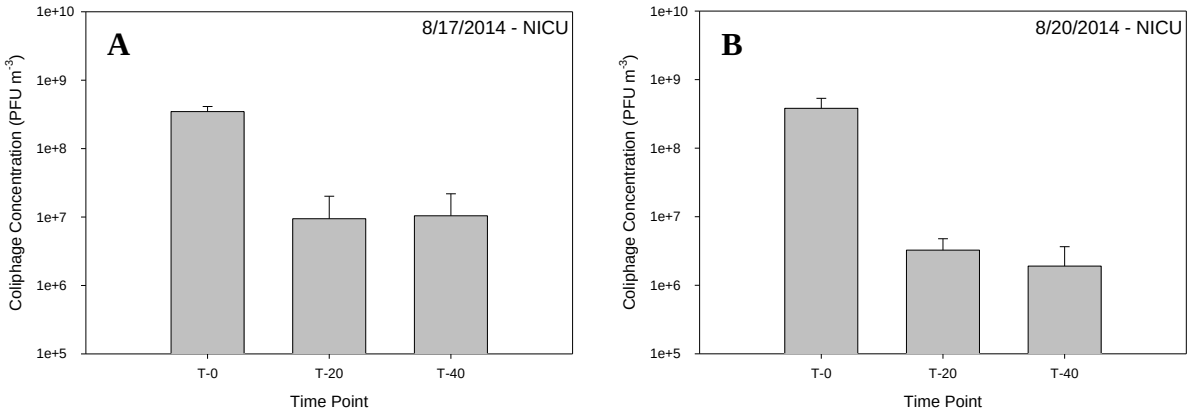

Figure 4. Coliphage results following air seeding and treatments in a neonatal intensive care unit procedure room on A) August 17 and B) August 20. Time points defined in Table 2. Detection limit equal to $1.0X10^5$ and represented as the minimum y-axis value shown in the figure.

The natural HVAC conditions in the NICU procedure room resulted in a 1.76 log removal of seeded coliphage. This rate was statistically different (p=0.028) compared to the PICU patient room natural HVAC removal of 2.46 logs. The NICU procedure room also had a significantly great air exchange rate (37.5 exchanges $hour^{-1}$) compared to the PICU patient room (12.4 exchanges $hour^{-1}$). Descriptive statistics for environmental conditions measured in each sampling room are provided in Table 3.

Table 3. Summary statistics of measured environmental parameters in each study room

Room	**Relative Humidity (%)**			**Air Temperature (°C)**			**Air exchanges (hour $^{-1}$)**
	Min.	Mean	Max.	Min.	Mean	Max.	Actual
PICU Patient Room	34.0	40.9	49.8	21.8	21.9	22.1	12.4
NICU Procedure Room	45.3	53.1	57.6	21.6	22.0	22.7	37.5

DISCUSSION

The Aerobiotix T1 unit provided improved airborne viral concentration reduction by about 0.5 logs compared to natural HVAC conditions in the PICU patient room. In the NICU procedure room, no measureable difference was detected using the Aerobiotix T1 and the natural HVAC system.

The NICU procedure room had significantly higher reductions of coliphage concentrations under the natural HVAC conditions compared to those measured in the patient room. The differences measured between the two rooms may be due in part to the differences in air exchange rates (12.4 air exchanges per minute in the PICU patient room and 37.4 air exchanges per minute in the NICU procedure room) which likely alter the rate at which coliphage settles onto surfaces or remains suspended in the air.

Future research should focus on additional investigations in the PICU patient room that incorporates fomite and air testing. Including fomite testing may highlight the Aerobiotix T1 capabilities to reduce the amount of aerosolized microbes that rapidly settle on surfaces.

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