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Respiratory Epidemiology Unit
Joint Departments of Epidemiology and Biostatistics and of Occupational Health

REPORT ON

ASSESSMENT OF GERMICIDAL UV LIGHTS IN THE SPUTUM INDUCTION ROOM AT THE MONTREAL CHEST INSTITUTE

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EXECUTIVE SUMMARY

In a test conducted by McGill University research team on the efficacy of Ultraviolet Air Purification. **A portable ultraviolet unit (Sanuvox P8000GX) was effective in reducing airborne viable bacteria (tuberculosis) by close to 90 percent and reduced bacterial concentrations at a rate equivalent to approximately 6 air changes per hour**.

The wall mounted (portable) commercially available ultraviolet light unit (Sanuvox P800GX) provided a very restricted band or plane in which the ultraviolet light shone into the air this should be very safe for workers because at eye level [less than 6 feet] the intensity of UV light in the room was less than 1% of levels measured outdoors on a cloudy day in early March.

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Initially proposed that airborne bacterial concentrations would be sampled before, during, and after sputum induction performed on three patients for each of five different experimental conditions. Two of the experimental conditions included use of a portable air cleaning device with a fan that drew air into an enclosed chamber where high-intensity UV lights was present (Sanuvox P800GX). This portable device would therefore draw bacterial laden air into the chamber where bacteria were killed. **We had shown in our laboratory that this unit (Sanuvox P800GX) was efficacious in reducing airborne bacterial concentrations by close to 90 percent.**

RESULTS

Twenty patients were studied in this phase of the assessment, for [4] patients for each of the experimental conditions. We have added these results to the previous results and express all results together. As shown in table 1, in total 60 patients have been studied with mean age of 40. Their average, duration was approximately 3.5 minutes. The most notable aspect of the environmental measures was that the humidity averaged 31 percent which would indicate that there should be no problem with the UV light efficacy on the basis of humidity as UV light efficacy is only reduced when relative humidity exceeds 70 percent. In addition, the hallway CO2 concentrations were high reflecting the fact that the hallway was often crowded with the patients waiting for different procedures.

Table 2 summarizes the results of concentrations of airborne colony forming units during all trials. In general when the exhaust fan was on, the baseline concentrations of airborne bacterial were similar in the room to those in the hallway, and the increase from baseline to peak was significantly less than the increase when the exhaust fan was off. This suggested the exhaust fan may have some influence on lowering phase peak concentration, and a significant effect on raising the baseline concentrations. However, these hallway bacteria are not considered dangerous or pathogenic bacteria because their source is humans in the hallway who are not suspected to have active TB.

When the exhaust was on overall air changes per hour were lower than when the exhaust was off. In part, this may reflect the fact that the entrainment of hallway air meant that the post sputum induction levels could not fall as low as when the exhaust fan was off and UV light only was on [i.e. this may have been artefactual]. However, with the exhaust Fan on, there are some clear and convincing differences in the calculated air change rates. In the 9 trials, with upper air UV on, the decline in concentrations considered equivalent to air changes per hour was greatest. The equivalent air change rates i.e. decline in airborne bacterial concentrations, with portable UV on were also higher than with exhaust only.

With the exhaust Fan off over all calculated air changes based on bacterial removal appeared to be higher. Overall, the upper air UV was not as good as the portable UV. However, calculated air change rates with upper air UV were much higher when the mixing fan was on compared to when the mixing fan was off during the decay phase. Equivalent air change rates were lower when the mixing fan was on during cough only than when the mixing fan was off throughout sputum induction partly because peak concentrations may have actually been higher because of poor mixing of the airborne bacteria. Therefore, part of the decay seen was due to continued mixing of air following the end of sputum induction which was not seen when the mixing fan was off during the sputum induction phase only. However, when the mixing fan was kept on throughout the, the efficacy of UV lights appeared to be close to that of the portable fan unit only.

Overall, it would appear that the portable fan unit and upper air UV are both efficacious and add to the effect of the exhaust fan. Given the differences in calculated air change rates when exhaust was on or off it is difficult to conclude that one is better than the other and safer to conclude that they appear to be equivalent in their effect.
Although the infection control committee did not want to embark in this aspect of the study, we have, nevertheless, looked at the effect of upper air UV lights on respirable and non-respirable bacterial counts. These results are shown in Table 3. When the exhaust fan was on it was difficult to detect an increase or decrease in respirable airborne respirable bacteria. As mentioned earlier, this can be explained by the entrainment of bacterial latent air from the hallway which tended to blunt any effect of experimental interventions within the sputum induction room.

However when the upper air UV light was on and exhaust Fan off there was an increase followed by a decrease in respirable bacteria which was in parallel to the total bacterial rise and fall. These trials were done earlier at a time when we were using mixing fan during cough only. However, the results of respirable particles appear to parallel the results of total and therefore we can infer that the apparent failure of UV light and/or exhaust to prevent the peak seen during and immediately following sputum induction was not because the bacteria were present in large particles which UV could not penetrate. Rather, this was a true event and therefore we concluded that this rise in airborne bacterial counts was real and not artefactual.
We were concerned as to why the upper air UV did not appear to be more effective. A possible factor is shown in the results of UV light intensity in the sputum induction room. These measurements taken on the 5th than of March 1998 at a time when outdoor UV intensity measured with the same instruments was 5 microwatts per centimeter square. By contrast, at the end of March on a sunny day at noon, the outdoor UV intensity was 40 microwatts per centimeter square.

It can be seen that the UV light produced light of adequate intensity on a horizontal plane at the same level as where the UV light was installed, i.e. approximately eight feet above the floor. However, measurements taken at a height of 5 to 6 feet showed very low levels of radiation. This is shown schematically in figure 1 "UV intensity measurements-vertical plane". It should be noted in this graph that the height above ground shown ranges only from 215 cm to 265 cm and that when measurements were taken at lower levels, i.e. 2,3,4,5, and 6 feet above the ground that the measurements were all less than .02 microwatts per square centimeter. In addition, as shown in the figure 2 "UV intensity measurements-horizontal plane", there was a rapid dropoff in UV intensity as we increase the distance from the source. Therefore, in summary, the UV light fixtures delivered light in the very narrow horizontal plane with high-intensity only in a portion of that total plane extending to approximately 80 cm from the UV light fixture. Therefore, many points in the room had low levels of irradiation, even some in the horizontal plane of UV light. So exposure of bacteria to this plane of UV light was relatively brief, and required good air mixing for sufficient exposure.

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Table 1: Patient and Experiment Characteristics

Patient Characteristics	
Number	60
Gender	46M, 14F
Mean age (y)	40 (range, 21-71)
Mean cough duration (s)	219
Experimental Conditions (n)	60
Exhaust on	29
All UV off	16
Upper air UV on	9
Portable UV on	4
Exhaust off	31
All UV off	2
Upper Air UV on	25
Mixing fan always on	9
Mixing fan on during cough	9
Mixing fan off	7
Portable UV on	4

Environmental Measures

	Temperature (mean, °C)	Humidity (mean, %)	CO_2 (mean, ppm)
Outdoor	13.1	57	350
Hallway	23	31	824

Table 2: Means of Airborne Bacterial Counts - All Trials[1]

	Hallway	pre	Peak	Post	Increase[2]	Decrease[3]	"ACPH"[4]
Exhaust on (n=29)	560	471	650	359	179	301	1.89
*all UV off (n=16)	770	675	786	472	110	314	1.61
*upper air UV on (n=9)	337	223	566	123	342	393	4.8
*portable UV on (n=4)	318	210	298	142	88	156	2.34
Exhaust off (n=31)	479	349	625	293	276	334	2.39
upper air UV on (n=25)	546	403	672	347	270	330	2.09
*mixing fan always (n=9)	430	180	418	79	238	339	5.26
mixing fan during cough (n=7)	633	521	830	585	308	247	1.12
no mixing fan (n=7)	696	533	804	442	271	394	1.89
*portable Uv on (n=4)	345	98	405	60	307	345	6.03

1. Airborne bacterial counts in CFU/m3,
2. Increase=Peak-Pre
3. Decrease=Peak-Post
4. Air changes per hour equivalent calculated based on decrease in bacterial concentrations from peak to post (see Methods)
* Most recent trials included here N=4 for each

Table 3: Total and Respirable Bacterial Counts[1]: Upper Air UV vs. Exhaust

	Hallway	Pre	Peak	Post	Increase[2]	Decrease[3]
Exhaust (n=4)						
Respirable		152	148	137	(-4)	11
Total	909	810	819	647	9	172
UV and mixing fan during cough (n=7)						
Respirable		70	105	81	35	24
Total	560	521	713	582	192	131

1. Airborne bacterial counts in CFU/m^3
2. Increase=Peak-Pre
3. Decrease=Peak-Post