Bacterial Spread in Public Washrooms: A Comparative Analysis of Hand Dryers, Paper Towels, and Ambient Air

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Abstract

Public washrooms are potential hotspots for bacterial dissemination, especially in high-traffic environments. This study compared bacterial contamination levels associated with three hand-drying methods: hand dryers, paper towels, and ambient air. Agar plates were exposed to each treatment in five different public washrooms at University of British Columbia (UBC), with three replicates per treatment. Following an 8-day incubation period, bacterial growth was observed almost exclusively on plates exposed to hand dryers. Statistical analysis, including a one-way ANOVA ($F(2, 42) = 49.48$, $p < 0.001$), and Post Hoc Tukey HSD tests, revealed significant differences in colony-forming unit (CFU) counts between hand dryers and both paper towels and ambient air, with an average difference of approximately 70 CFUs. Most of the towel and ambient treatments had 2 or fewer CFUs. Qualitative observations highlighted the influence of environmental factors on bacterial growth, such as ventilation and washroom cleanliness. Notably, washrooms with higher foot traffic and poorer ventilation exhibited the highest bacterial growth. These findings suggest that hand dryers, particularly in poorly maintained environments, may contribute to bacterial dissemination and that hand dryers as well as the washrooms they're in require

maintenance to be considered a sanitary hand drying option. Further research is needed to explore strategies for reducing bacterial spread in public facilities.

Introduction

The spread of bacteria in public washrooms is a significant concern for public health, particularly in high-traffic areas such as universities. These facilities serve as hotspots for microbial contamination, with surfaces and air frequently harboring a wide array of bacteria and fungi. One of the most scrutinized aspects of public washroom hygiene is the hand-drying method, which has been shown to influence bacterial dissemination. Studies have highlighted the potential of hand dryers to circulate bacteria from the washroom environment, spreading them onto users' hands and into the surrounding air. This is in contrast to paper towels, which are often considered more hygienic as they trap bacteria and do not promote aerosolization (Huesca-Espitia et al, 2018; Ma et al, 2020). However, despite these concerns, hand dryers remain a popular option due to their cost-effectiveness, environmental appeal, and reduced paper waste.

While previous research has compared bacterial contamination from hand dryers and paper towels, many studies have not included ambient air as a baseline control or explored environmental factors like ventilation and cleanliness. Furthermore, few studies have evaluated how different hand dryer models or washroom conditions (e.g., traffic levels, cleaning frequency) affect bacterial spread. Such factors could play a critical role in determining the overall hygiene of hand-drying methods.

This study investigates bacterial contamination levels associated with three drying methods: hand dryers, paper towels, and ambient air. Using agar plates exposed to each treatment in five different public washrooms at the University of British Columbia (UBC), this experiment aims to provide a comparative analysis of bacterial dissemination. By integrating quantitative data with qualitative observations, this study seeks to fill gaps in existing research and contribute to the ongoing discussion on the best practices for hand hygiene in public facilities.

Methods

This experiment was divided up into two periods: the sample collecting period and the observation period. Agar plates were labelled with location and treatment number prior to data collection. The control plates were left in the lab while samples were being collected. During the sample collecting period, the research team went around to the five study locations in UBC and collected data at each one. The study locations were the following: first floor men's washroom in Irving K. Barber Learning Center (IKB), first floor handicap washroom in AMS Nest (NEST-F1), second floor men's washroom in AMS Nest (NEST-F2), second floor men's washroom in Life building (LIFE), and second floor gender neutral washroom in Henry Angus Building (SAU).

All three treatments were collected at the same time at each location. One person held a timer and three others each conducted one of the treatments. All treatments were performed with the plate facing upward. The person collecting the ambient air treatment stood with an open agar plate at about elbow height (roughly 125 cm above the floor) at a position close to the hand washing stations. The person collecting the hand dryer

treatment used a ruler to measure 5 cm from the nozzle of the hand dryer and held the agar plate at that distance while simultaneously moving it in a small back and forth motion to activate the hand dryer. The person collecting the paper towel treatment stood at a sink or counter and grabbed the first paper towel from the dispenser, folded it into a square roughly the same size as the agar plate, and pressed it firmly onto the agar plate. The next replicate was done with the next paper towel in the dispenser. When signalled by the timer holder, all treatments began by taking the lid off and all treatments ended by putting the lid back on. After all agar plates were collected, observations were made about the washroom and the equipment tested before heading back to the lab. All plates were wrapped with parafilm after returning to the lab, then photos were taken of them before putting them into the incubator at 37℃.

During the observation period, the agar plates were pulled out of the incubator about every 24 hours and photos were taken of them to document the growth before returning them to the incubator. The process of photo taking on average lasted 30 minutes and the temperature of the agar plates did decrease during this period. This was repeated every day for 8 days (except the two weekend days, Nov 2nd and Nov 3rd), where the plates were disposed of after photo taking on the 8th day.

Results

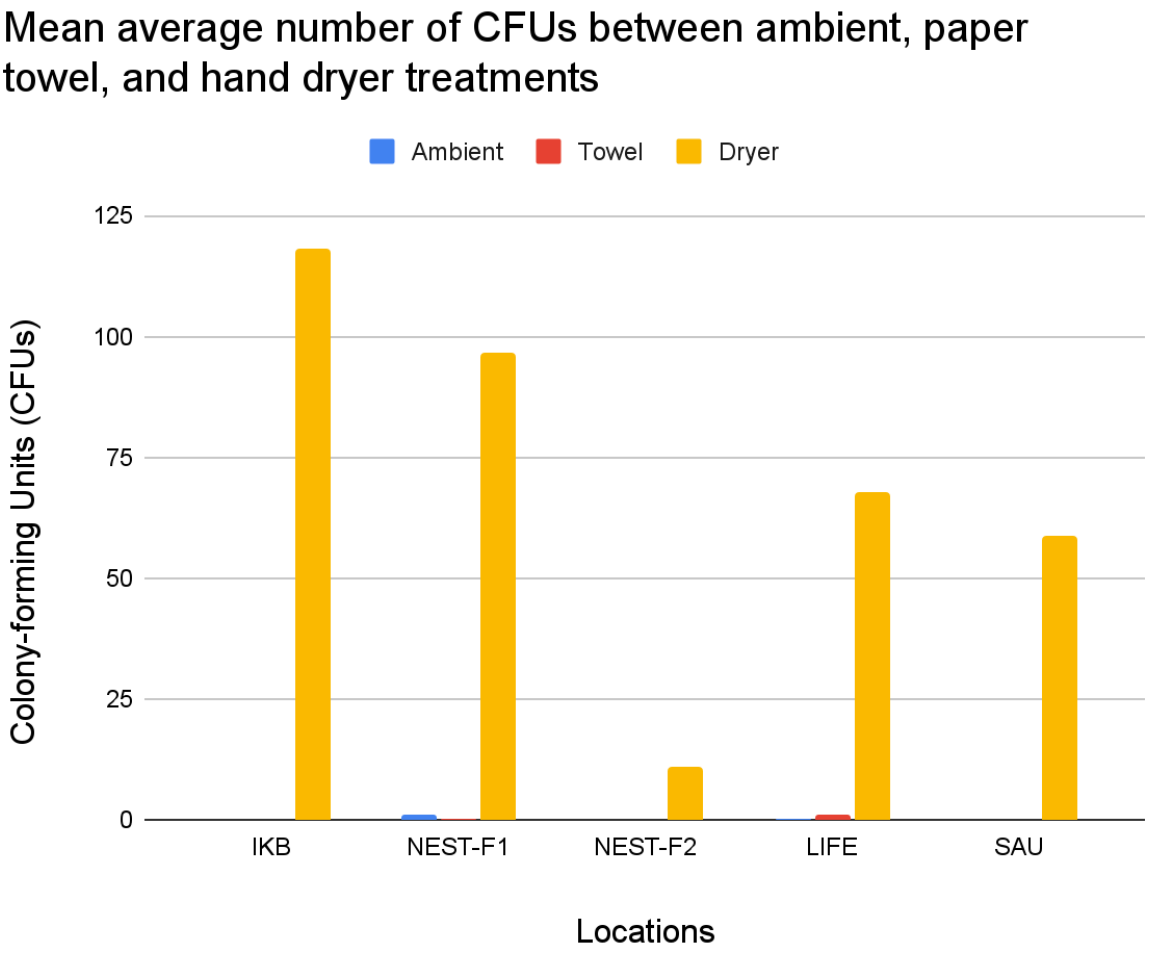


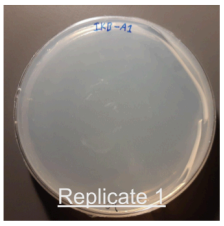
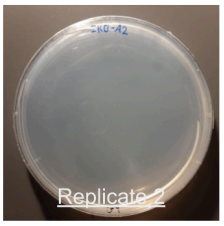
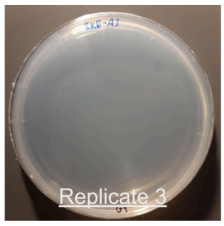
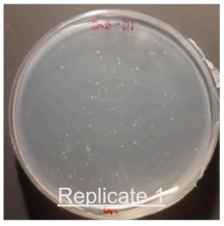
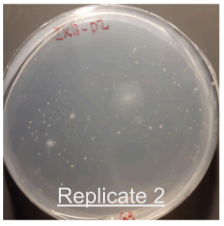
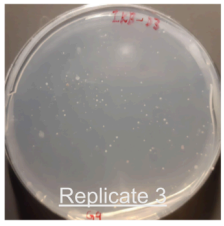
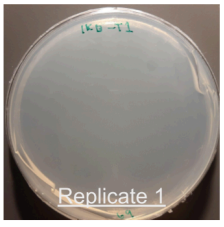
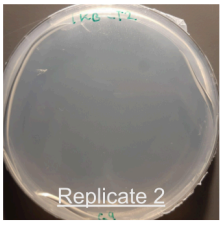
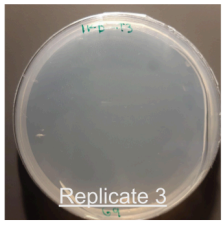
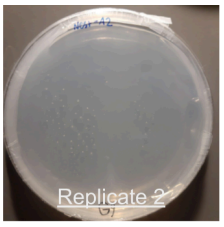
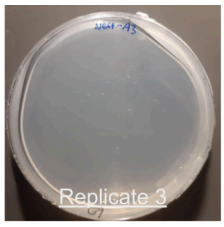
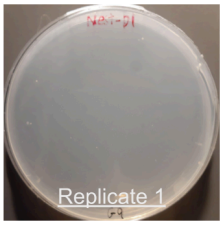
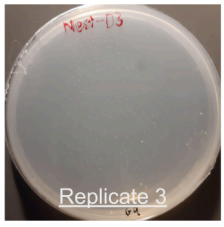
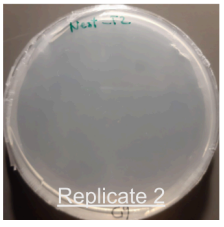
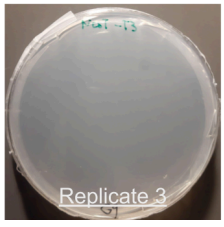
Figure 1. Mean average CFU count of all treatments on the final day of observation. Each location had low variation within each treatment so the mean average data is reliable.

The CFU counts for each treatment across five locations on the final observation day were recorded and plotted in Figure 1. The range of CFU count in dryer treatments vary greatly between different locations but all of the ambient air and towel treatments show little to no bacterial growth.

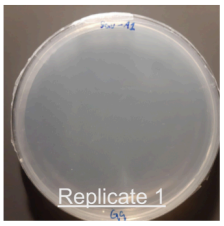
The small solid white dots in each growth plate are bacteria colonies while the larger, slightly transparent white circles are fungi colonies (Figure 2). The species of bacteria were not identified but it is expected to consist of the following four phyla: *Actinobacteria*, *Bacteroidetes*, *Firmicutes* and *Proteobacteria* according to previous research (Flores et al, 2011). The microbial biogeography of the growth plates are consistent with previous research as both bacterial and fungi colonies were present (Ma et al, 2020).

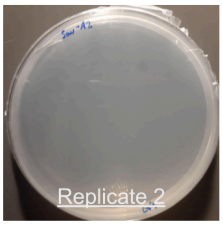
The one-way ANOVA test indicated a statistically significant difference in bacterial growth between treatments ($F(2,42) = 49.48$, $p < 0.001$)(P-value 9.05×10^{-12}). Plates exposed to hand dryers exhibited significantly higher CFU counts compared to those exposed to paper towels or ambient air (Figure 1).

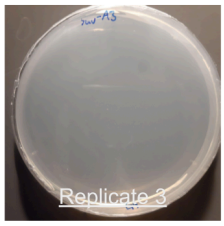
A Post Hoc Tukey HSD analysis revealed a significant difference between ambient air treatment and hand drier treatment pair with an average difference of 70.07 CFUs. ($Q = 12.18$, $p < 0.001$) The same significant difference is true for the paper towel and hand drier treatment pair which had an average difference of 70.13 CFUs. ($Q = 12.19$, $p < 0.001$)

IKB Ambient	 Replicate 1	 Replicate 2	 Replicate 3
IKB Dryer	 Replicate 1	 Replicate 2	 Replicate 3
IKB Towel	 Replicate 1	 Replicate 2	 Replicate 3
NEST-F2 Ambient	 Replicate 1	 Replicate 2	 Replicate 3
NEST-F2 Dryer	 Replicate 1	 Replicate 2	 Replicate 3
NEST-F2 Towel	 Replicate 1	 Replicate 2	 Replicate 3

SAU Ambient







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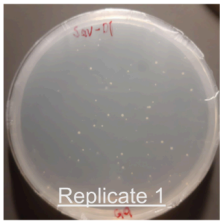

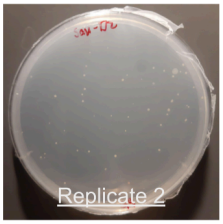

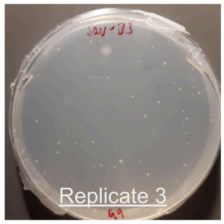

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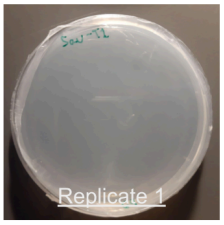
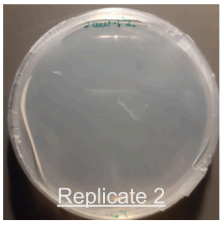
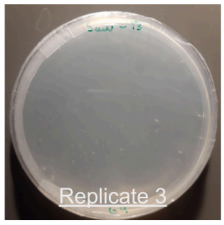
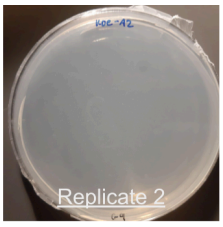


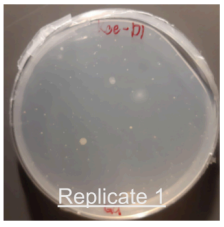


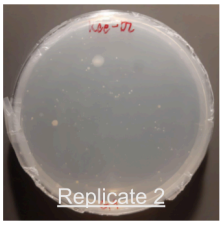


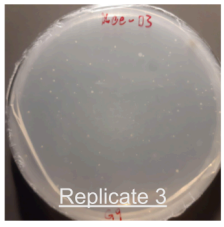
NEST- F1 Ambient



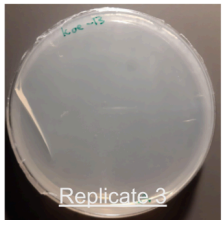
NEST- F1 Dryer







NEST- F1 Towel



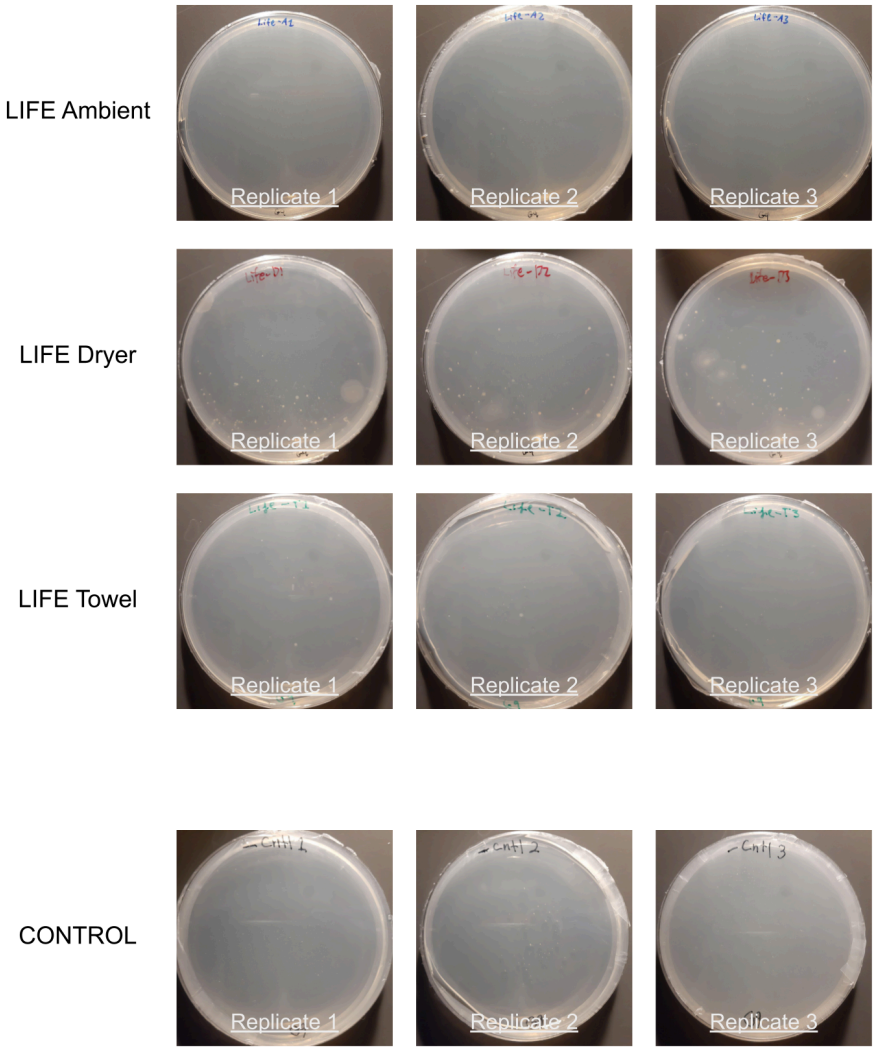


Figure 2. Photos of each plate on November 6th. Dryer replicates have noticeably more CFUS than non-dryer replicates.

Qualitative Observations By Location

The IKB washroom treatments showed the highest amount of bacterial growth and was the first plate to develop bacterial colonies. It had 4 stalls and 2 urinals with decent air ventilation. However the air smelled poor, possibly due to multiple users in the stalls

during data collection. The hand dryer model was a Dyson Airblade 9kj equipped with HEPA filter and was about 2 meters away from the washroom stalls.

The Life building washroom plates showed moderate bacterial growth. The hand dryer was also a Dyson Airblade V HUO2 with a HEPA filter. The washroom had good ventilation, and a cleaning session was underway during data collection, which could have reduced bacterial load.

The Nest first floor washroom, a handicap single-use facility, had relatively low bacterial growth but notable contamination of the hand dryer's bottom tray. The ToTo CleanDry's dirty state could have contributed to airborne bacteria during data collection.

The Nest second floor men's washroom had the lowest bacterial growth and was noted to be the cleanest and least smelly. Sampling occurred earlier in the morning. The hand dryer, a ToTo CleanDry, showed no signs of recent use, and the washroom lacked adequate ventilation.

The Sauder second floor gender neutral washroom exhibited moderate bacterial growth. The ventilation was good, and the ToTo dryer showed no signs of recent use. Three of the stalls were occupied during data collection.

Discussion

The results and observations reveal interesting patterns in bacterial growth linked to environmental and operational conditions of the washrooms. Firstly, agar plates exposed to hand dryer air showed significantly more bacterial growth, consistent with findings from other literature sources (Ma et al, 2020; Suen et al, 2019). Based on

results from the one-way ANOVA test and Post Hoc Tukey HSD analysis conducted on the CFU data, the researchers reject the null hypothesis and the results support the alternate hypothesis that hand dryers deposit more bacteria than other drying methods. Washrooms with poor ventilation and higher foot traffic (e.g., IKB) showed significantly higher bacterial growth on hand dryer plates, supporting the prediction that hand dryers can circulate bacteria from their surroundings. Conversely, cleaner washrooms with better ventilation (e.g., NEST-F2 and Life building) exhibited lower bacterial growth, suggesting that environmental factors like ventilation and cleanliness play a critical role in bacterial dissemination.

The presence of HEPA filters in Dyson dryers (Life and IKB) did not appear to reduce bacterial growth significantly, potentially due to high bacterial loads in the surrounding air or insufficient maintenance of the devices. This is contrary to the results obtained by Huesca-Espitia et al. (2018) where the HEPA filters reduced the “bacterial deposition by hand dryers ~4-fold”. In contrast, the ToTo dryers in Nest, Sauder, and Nest first floor washrooms showed varying results, emphasizing that the state of the dryer and surrounding cleanliness are equally important in mitigating bacterial spread.

The low CFUs in the Life building washroom is likely due to the time of the measurement; the samples were collected around 5 minutes after a custodian had just cleaned the washroom. The exact methods of the cleaning process is unknown to the researchers but it is assumed to be very effective at eliminating both airborne bacteria and surface bacteria on the hand dryer.

Interestingly, the NEST first floor washroom, despite being a single occupant washroom, showed the most contamination on the dryer's tray, which could explain the bacterial presence on plates. This underscores the importance of routine cleaning and maintenance of hand dryers to ensure their efficacy in reducing bacterial spread.

Conclusion

Our study highlights the impact of both hand dryer type and environmental conditions on bacterial contamination levels in public washrooms. The findings suggest that hand dryers, particularly those in high-traffic or poorly ventilated environments, may contribute to the spread of bacteria, highlighting the need for better maintenance and strategic placement in public facilities.

Acknowledgements

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Appendix

Table 1. CFU counts of all treatments on the final day of observation (Nov 6th)

	Ambient 1	Ambient 2	Ambient 3	Towel 1	Towel 2	Towel 3	Dryer 1	Dryer 2	Dryer 3
IKB	0	0	0	0	0	0	133	112	109
NEST-F1	2	2	0	0	1	0	113	87	90
NEST-F2	0	0	0	0	0	0	11	12	10
LIFE	0	1	0	2	1	0	72	57	74
SAU	0	0	0	0	0	0	63	55	58
CTRL	0	0	0	-	-	-	-	-	-