TITLE: REVIEW ON THE EFFECTIVENESS OF HAND DRYING SYSTEM USED IN WASHROOM

Author: **Sultana Kudrati khoda, Iaain Wheller, Andrew Stott**
University of Wolverhampton, School of Architect and Built Environment

Abstract: Hand washing in public and commercial spaces is ubiquitous in our daily life. Hand hygiene involves washing of hands followed by drying with single-use paper towels or electric hand dryers. The selection of hand-drying methods may be influenced by cost, service/cleaning issues of washrooms, footfall, space availability, and access to power sources etc. To support Moje Solutions R&D activities, the University of Wolverhampton EnTRESS Project undertook a comprehensive analysis, and identified the several issues associated with the mechanical air-blown hand drying process. The EnTRESS project collaborated with Moje Solutions undertook an intensive review on leading hand drying solutions currently in the market and made a case study on the effectiveness of the HYGIENE ACE hand dryer splash guard which is invented by Moje Solution's research team.

Introduction

Hand washing is a common practice in everyday life. In commercial and public washrooms hand hygiene involves the washing of hands with soap followed by drying with either paper towels (PTs), cloth towels, electric warm hand dryers or jet air dryers (JADs). The purpose of washing hands after using washrooms, or touching any unhygienic objects, is to remove potentially harmful micro-organisms from the hands. It is well documented that a variety of bacteria can spread from the washroom environment by the person who washed their hands but unknowingly touched the JAD surface, or by inhaling the air by the users or non-users of JAD. A common practice of hand drying is rubbing hands under a JAD or using PT.

Figure 1: Hand washing

Figure 2: Hand Drying (JAD)

Figure 3: Hand Drying (PT)

A lot of people shake their hands to remove the excess water from their hands which creates a wet floor within the washroom, and this is often due to the poor efficacy of hand driers. Smith and Lokhorst, 2009 stated that wet hands can spread up to 1,000 times more bacteria than dry hands because it is easier for bacteria to transfer between surfaces, and bacteria grows well in damp conditions. Thus, proper hand drying is essential to protect bacterial contamination within this public environment.

Critical factors in the effectiveness of hand drying includes the speed of drying, degree of dryness, effective removal of bacteria, and the prevention of cross-contamination (Huang *et., al*. 2012). With the effectiveness of hand washing against microbial contamination and infection being highly dependent on the hand drying process. There are contrasting opinions within the research community as to which hand drying methods provide the best hygiene impacts (Kasapoglu, *et*. *al*., 2022). A group of researchers suggested that hand dryers are a source of bacterial transmission rather than being effective in ensuring hand hygiene (Best *et. al*., 2018, Alharbi *et. al*., 2016, Best *et. al*., 2014). Results also evidenced that jet air and warm air dryers are responsible

for increased bacterial aerosolization when drying hands for both users and bystanders alike (Best *et. al.*, 2014).

Several studies were supported by Best, *et. al.*, 2018 and considered that hand-drying methods are associated with a greater risk of transferring residual microbes from hands after handwashing due to the aerosolization of microbes e.g., *Staphylococcus aureus* and *Escherichia coli*, and for viruses, including norovirus and influenza viruses. Best and Redway (2015) experimented the potentiality of hand drying on microbial dispersion using hand dryers (paper towel, continuous roller towel, warm air dryer and jet air dryer) in washroom and found that jet air dryer dispersed more liquid compared to others (Figure 4).

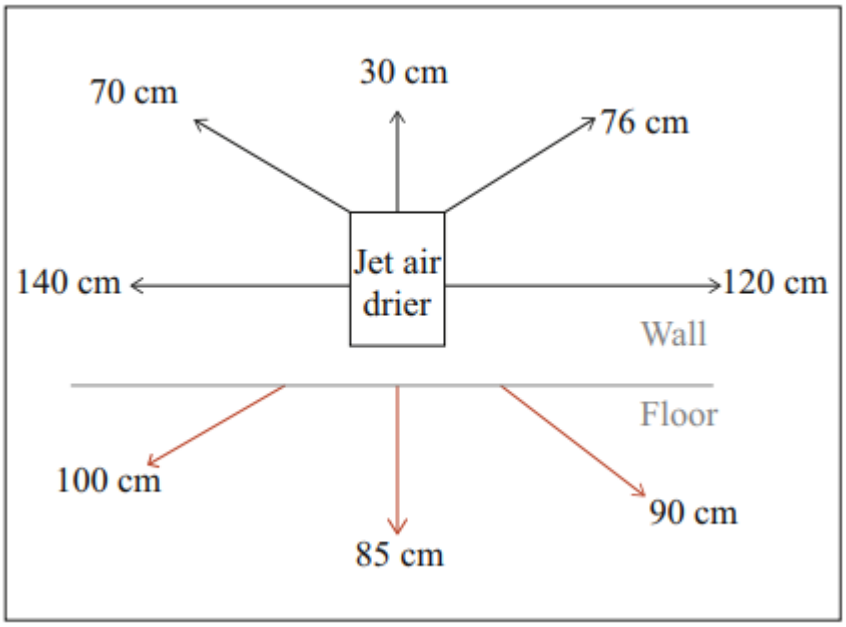

Figure 4: Distance travel by bacteria from jet air dryer (Reference: Best *et. al.*, 2014)

But another report showed that air dryers were bacteriologically safe (Matthews and Newsom, 1987). A study by Taylor *et. al.*, 2000 showed that there was no significant difference in the number of bacteria on the hand between drying hands with a hand dryer vs drying with a paper towel.

The effectiveness of hand washing against microbial contamination is highly dependent upon the hand drying process itself, although the above literature suggests

that there are controversial views on which hand drying methods are best in terms of hygiene (Kasapoglu, *et. al*., 2022).

In addition to this, both paper towels and hand dryers also have their own sustainability challenges: The long-term sustainability of drying our hands using paper towels adds further challenges: Harrison *et. al*., 2003 reported that paper-towel dispensers and hands can spread bacteria if either one is contaminated thus, the design, construction, and positioning of these devices is important factors for using paper towel. Best *et., al.* 2014 highlighted that paper towels require areas for material disposal where the bacteria can continue to spread. The author also noted that those sacks of used paper towels could be a possible source of contamination in operating theatres. On the other hand, using paper towels might be more costly compared to air dryers, as they require frequent replacement (with paper towels being a single use product -take, make, throw) whereas air dryers usually require little maintenance (mechanical hand drying equipment which is reliant upon electricity to operate during its use). In a report, it is evident that over 3,000 tons of paper towel waste is generated every day in the US alone and to make one ton of paper towel, 17 trees are cut down and 20000 gallons of water are consumed. Decomposition of these used paper towel is another concern as it produces methane gas a which is 21 times more potent than CO_2 in term of global warming potential.

(Source:https://www.creighton.edu/fileadmin/user/sustainability/docs/creighton-9.pdf)

The above discussion provides an evidence base for the development and enhancement of hygienic hand drying practices. The selection of hand-drying methods within commercial and public washrooms may be influenced by several factors including cost, maintenance, footfall, design of dryers, space availability and access to a power source.

Bacterial transmission in Washrooms

There are different sources of bacterial dispersion in washroom. Bacteria is spread around the washroom through contact with critical areas within the environment, including the sink, toilet cubicles, urinals, doorplate, floor under the JAD or PT unit, and the outside casing of the JADs or the outside of a PT dispenser Figure 5).

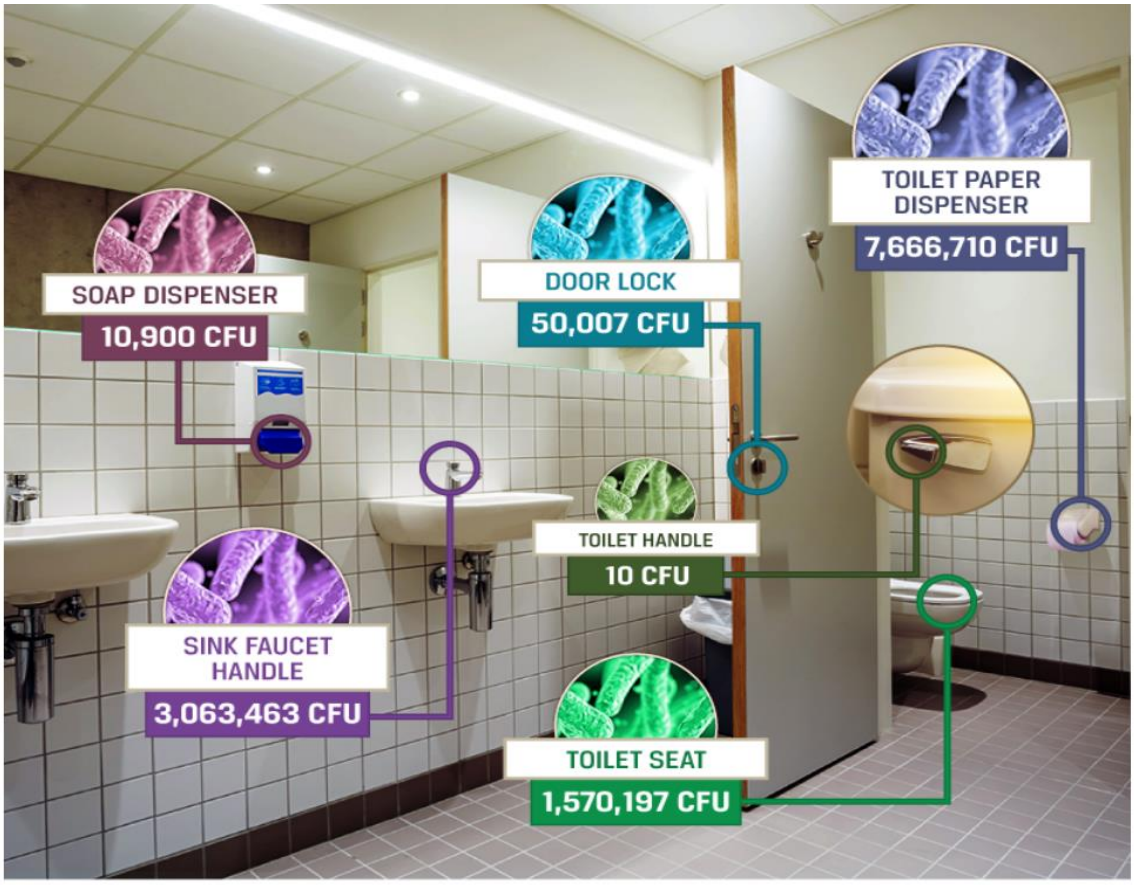

Figure 5: Harbour of different microorganisms in washroom
(Source: https://www.seniorliving.org/research/restroom-germs/)

The infographic in Figure 6 below, reflects the type of bacteria found in washrooms and their adverse impact on human health. It also demonstrates the challenges faced by inventors and manufacturers in developing suitable products, capable of reducing or alleviating more so, the presence of human bacteria in washrooms. A recent study led by University of Leeds Professor Mark Wilcox showed that bacteria can be spread into the air, onto users and those nearby by both jet and warm air hand dryers (Figure

6). Although PT showed safer than air drying but there are sustainability issues that needs to be addressed.

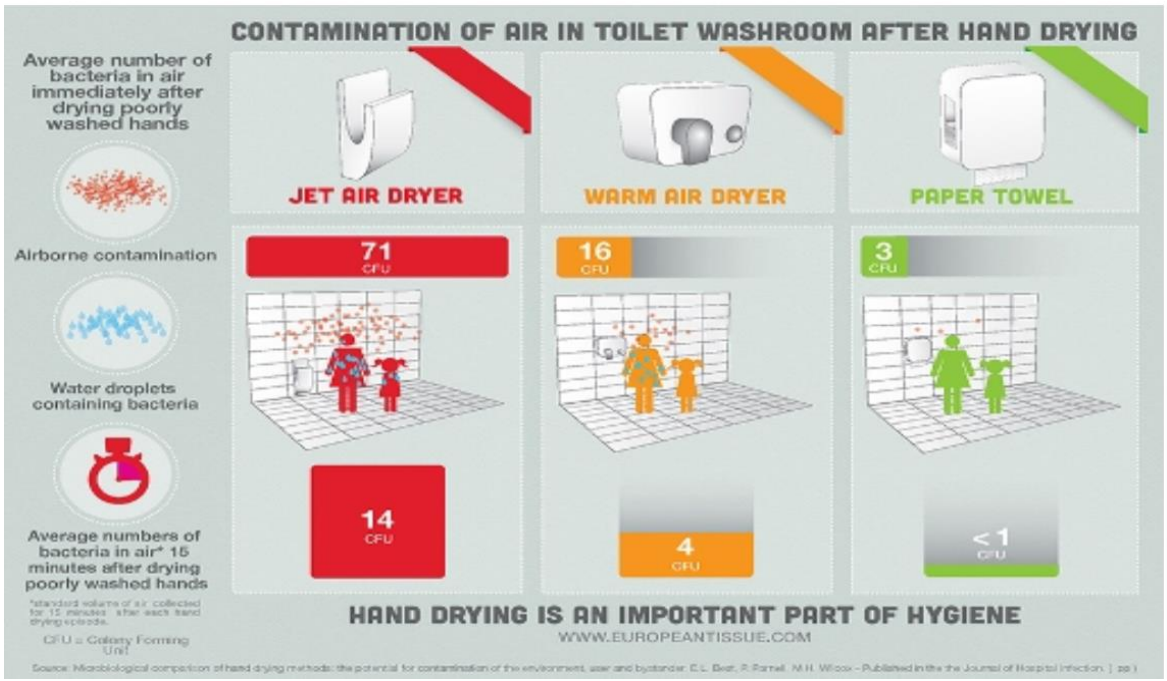

Figure 6: Infographic (Reference: University of Leeds Health news, 20/ 11/2014)

Type of bacteria found in washrooms and the impact of this bacteria on human health.

Alharbi, *et. al*., 2016 investigated the bacterial contamination of hand air dryers in washrooms and found that *Staphylococcus haemolyticus, Micrococcus luteus, Pseudomonas alcaligenes, Bacillus cereus* and *Brevundimonad diminuta/vesicularis* were emitted from all of the dryers sampled in the study. With 95% of dryers studied also showing evidence of the potential pathogen *S. haemolyticus*.

The environmental impact of Hand Dryers in washrooms.

A comparative research study of public washrooms was undertaken across three countries (UK, Italy, and France) seeking to understand bacterial presence from sample

areas including washroom air, door, floor, box, sink and dust. Both paper towel and jet air dryer scenarios were analysed in each country see results in Table 1.

Table 1: Presence of bacteria indifferent parts of washroom in different countries (Reference: Best *et. al.*, 2018)

Comparison of data for the paper towel and jet air dryer washrooms in each country

Washrooms	Mean footfall (people/h)	Mean temperature (°C)	Median total aerobic bacteria (cfu) recovered [a,b]					
			Air	Door	Floor	Box	Sink	Dust
Paper towel ($N = 60$)								
UK	93	21.9	5	1	40	9	85	115
France	9	23.4	5	12	24	9	37	300
Italy	10	27	5	<1	<1	<1	<1	75
Jet air dryer ($N = 60$)								
UK	86	22.1	6	15	200	200	63	145
France	7	23.2	1	5	190	300	132	300
Italy	10	27	0	0	<1	100	<1	20

[a] Volume of air sampled was 1500 L, equivalent to 20 L per agar plate. Approximate surface area sampled was 10 × 10 cm per site, equivalent to 0.2 cm^2 per agar plate.
[b] Significant differences highlighted in text.

It was found that samples from the UK on average resulted in more bacterial recovery when compared to France and Italy, and higher concentrations in environments with jet air dryers when compared to paper towels. It was noted that the former results may have been due to higher footfall in UK washrooms compared to others. There was also a lower presence of bacterial entities within the air and door samples compared to the floors, sinks and dust in both drying scenarios, with the PT dispenser having less bacteria than JAD surface.

Mutters and Warnes, 2019 investigated the hand drying method to test the presence of bacteria. They found very few numbers of transient and residential bacteria remained on the skin if hands were dried with a jet air dryer and drying hands with paper towels increased the number of resident bacteria, including potentially pathogenic species, released from the users' skin, compared to a jet air dryer. It also reduces the risk of infection transmission via touch.

When considered, it is therefore crucial to introduce a safe, hygienic hand washing and drying systems within public and commercial washrooms.

Hygiene Ace have conducted background research and a literature review in collaboration with the EnTRESS (Environmental Technology Resource Efficiency Support Services) project at the University of Wolverhampton to understand the hygiene challenges related to the hand dryer market. An intensive review has been conducted on available academic papers and case studies within this sector. Critical findings from the research include:

- Newer/effective hand dryers push water off hands using concentred air pressure, forcing water off the hands of the user.
- Water is pushed by concentrated air pressure, which sprays into the washroom.
- Puddles of water gather on the floor, that not only contain possible harmful bacteria, but also create serious slip and trip hazards.
- Splashed water on the floor also creates very unfriendly grounds for persons using walking sticks.
- Bacteria/germs are contained in the spray which then spreads around the washroom, thereby creating a perfect breeding ground for thousands of colonies of harmful bacteria in the shape of mould between the tiles under hand dryers.
- The emittance of odour is due to the discoloration of grout on the tiles.
- The situation results in a lack of eco-friendly surroundings in washrooms.

HYGIENE ACE address these sector challenges through their innovative Smart Splash Guards, which offer retrofit splash guard solutions to capturing and storing the excess water (Figure 7). When factored into an existing washroom cleaning regime this product can help to create a more hygienic environment and lower longer-term maintenance costs.

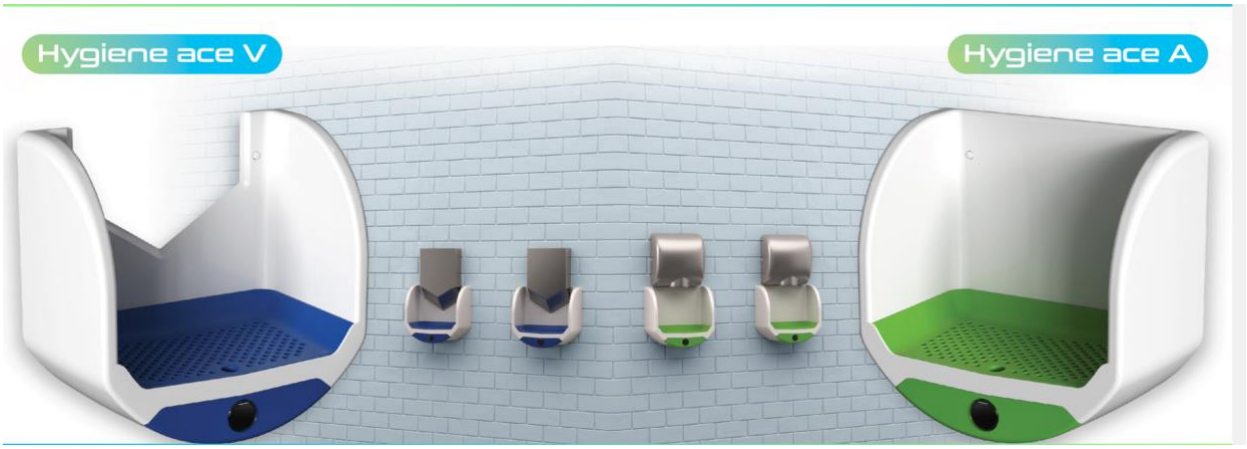

Figure 7: HYGIENE ACE hand dryer splash guards (https://hygieneace.com/home/)

The overall advantages of HYGIENE ACE hand dryer splash guards are:

- Efficiently collects excess splashed water from the user's hands.
- Preventing mould and mildew build-up on wall tiles and flooring.
- Universal fitting to fit under most hand dryers.
- Making hand drying more hygienic, without obstructing performance.
- Designed to improve Health & Hygiene standards in washrooms.
- Reducing cleaning cost and use of harmful cleaning products.
- Enhancing hand dryer's performance & customer experience.
- Helps creating safer environments in washrooms.
- Reducing washrooms slip & trip hazards.
- Disabled users friendly.

Hygiene Ace A™

Along with the above benefit Hygiene Ace A™ works perfectly with various commercial hand dryers. It has three components (the main bodyguard, the tray, and the water drawer compartment) work together to prevent water splash, cross-contamination, mould, damps, and bacterial colonies on the wall. Additionally, all parts can kill most germs on contact as the sleek

design and the built-in antimicrobial/Nano coating can make further reduce the spread of germs and cross-contamination.

Hygiene Ace V™

Similar features and functionality of the Hygiene Ace A, the Hygiene Ace V is introduced to fit under the Dyson Air Blade V™ and similar V blade hand dryers.

Demonstration of Hygiene Ace Water Splash Guard

Moje Solutions Ltd organized a demonstration session on the efficiency of splash guard in Science Park at Wolverhampton. There were two sets of hand drying system installed-i.e., only hand dryer (Figure 8), hand dryer with water splash guard (Figure 9). Around 70 people volunteered to see the performance of the splash guard. The volunteers used both hand drying system and expressed their remarks on the efficiency of the splash guard. It was noted that hand dryer with splash guard resulted best performance compared to hand dryer with no splash guard. All people were happy with the effectiveness of the HYGIENE ACE hand dryer splash guard as they found that the water guard protected their face/ body from water splash, it also restricted the floor from flooding with water during hand drying. Thus, they recommended the HYGIENE ACE water splash guard could be installed in all public washroom.

Figure 8: Demonstration of hand drying without water splash guard

Figure 9: Demonstration of hand drying with water splash guard

Conclusion:

The University's opinion of the Moje Solution's HYGIENE ACE hand dryer splash guard products is that they represent an enhanced method of containing bacterial contamination, compared with current marketplace solutions, and have the following potential benefits:

- Efficiently collecting excess splashed water from the user's hands.
- Preventing mould and mildew build-up on wall tiles and flooring.
- Universal fitting to fit under most hand dryers.
- Making hand drying more hygienic, without obstructing performance.
- Reducing cleaning cost and use of harmful cleaning products.
- Enhancing hand dryer's performance & customer experience.
- Helping to create safer environments in washrooms – e.g., reducing washrooms slip & trip hazards.

Reference:

Alharbi [a], S. A., Salmen[a] S. H., Chinnathambi[a], A., Alharbi[a], N. S., Zayed[a], M. E., Al-Johny[b], B.O. and Milton Wainwright[ac], M. 2016. Assessment of the bacterial contamination of hand air dryer in washrooms. Saudi Journal of Biological Sciences, Volume 23, Issue 2, Pages 268-271.

Best [a] E.L., Parnell [a], P., Wilcox [a b], M. H. 2014. Microbiological comparison of hand-drying methods: the potential for contamination of the environment, user, and bystander. Journal of Hospital Infection. 88 :199-206.

Best, E.L. and Redway, K. 2015. Comparison of different hand-drying methods: the potential for airborne microbe dispersal and contamination. J Hosp Infect. 89:215-217.

Best[a], E., Parnell[a], P., Couturier [b], J., Barbut[b], F., Le Bozec[b], A., Arnoldo[c], L., Madia[c], A., Brusaferro [c], S. and Wilcox[ad], M.H. 2018. Environmental contamination by bacteria in hospital washrooms according to hand-drying method: a multi-centre study. Journal of Hospital Infection (100) 469-475.

Harrison, W. A., Griffith, C. J., Ayers, T., and Michaels, B. 2003. Bacterial transfer and cross-contamination potential associated with paper-towel dispensing. Am J Infect Control. 31:387-391.

Huang [ab], C., Ma[b], W. and Stack [c], S. 2012. The Hygienic Efficacy of Different Hand-Drying Methods: A Review of the Evidence. Mayo Clin Proc. 87(8): 791–798.

Kasapoglu[a], S., Parlak-Yetisen [b], L., Ozdemir [b], A., and Dikmen[b] D. 2022. Assessment of the effect of hand dryers used in shopping malls on hand hygiene. American Journal of Infection Control. Page1–5.

Matthews J, Newsom SWB. 1987. Hot air electric hand driers compared with paper towels for potential spread of airborne bacteria. J Hosp Infect. 9:85–88.

Mutters[a], R. and Warnes[b], S. L. 2019. The method used to dry washed hands affects the number and type of transient and residential bacteria remaining on the skin. Journal of Hospital Infection. 101, page 408-413

Smith, J.M. and Lokhorst, D.B.2009. Infection control: can nurses improve hand hygiene practice? J. Undergraduate Nurs. Scholarsh. 11 (1), 1–6.

Speers, J. R. and Shooter, R.A. 1967. Shedding of bacteria to the air from contaminated towels in paper sacks. Possible significance for operating rooms. Lancet. 2:301-302.

Taylor, J.H., Brown, K.L., Toivenen, J. and Holah, J.T. 2000. A microbiological evaluation of warm air hand driers with respect to hand hygiene and the washroom environment. J Appl Microbiol.89:910–919.

https://www.creighton.edu/fileadmin/user/sustainability/docs/creighton-9.pdf)

https://www.seniorliving.org/research/restroom-germs/

https://hygieneace.com/home/