



ORIGINAL ARTICLE

Assessment of the bacterial contamination of hand air dryer in washrooms



Sulaiman Ali Alharbi ^{a,*}, Saleh Hussein Salmen ^a, Arunachalam Chinnathambi ^a,
Naiyf S. Alharbi ^a, M.E. Zayed ^a, Bassam O. Al-Johny ^b, Milton Wainwright ^{a,c}

^a Department of Botany and Microbiology, College of Science, King Saud University, Riyadh 11451, Saudi Arabia

^b Biological Sciences Department, Faculty of Science – King Abdulaziz University, Saudi Arabia

^c Department of Molecular Biology and Biotechnology, University of Sheffield, S102TN, UK

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Abstract The present study was carried out, using standard techniques, to identify and count the bacterial contamination of hand air dryers, used in washrooms. Bacteria were isolated from the air flow, outlet nozzle of warm air dryers in fifteen air dryers used in these washrooms. Bacteria were found to be relatively numerous in the air flows. Bacterially contaminated air was found to be emitted whenever a warm air dryer was running, even when not being used for hand drying. Our investigation shows that *Staphylococcus haemolyticus*, *Micrococcus luteus*, *Pseudomonas alcaligenes*, *Bacillus cereus* and *Brevundimonad diminuta/vesicularis* were emitted from all of the dryers sampled, with 95% showing evidence of the presence of the potential pathogen *S. haemolyticus*. It is concluded that hot air dryers can deposit pathogenic bacteria onto the hands and body of users. Bacteria are distributed into the general environment whenever dryers are running and could be inhaled by users and none-users alike. The results provide an evidence base for the development and enhancement of hygienic hand drying practices.

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1. Introduction

Hand drying is the last part of the hygiene procedure in a public washroom; if the washroom is well-designed, the number of

surfaces which the user subsequently touches will be limited or reduced to near zero. Hygiene of hands is an essential component for controlling the spread of infection (Larson, 1981; Lowbury et al., 1970). Wet hands can spread up to 1000 times more bacteria than dry hands (Smith and Lokhorst, 2009). This is because water transfers easily between surfaces and because bacteria thrive in damp environments (Redway and Fawdar, 2008). It is critical therefore, that hands are not contaminated with bacteria as the result of the drying process (Harrison et al., 2003).

Evidence regarding whether hand-drying methods vary in their tendency to aerosolize, and so transmit microorganisms,

* Corresponding author.

E-mail address: sharbi@ksu.edu.sa (S.A. Alharbi).

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is conflicting (Taylor et al., 2000; Ansari et al., 1991; Matthews and Newsom, 1987; Blackmore and Prisk, 1984; Blackmore, 1989; Meers and Leong, 1989). Various studies recommend that drying hands with warmed air is connected with amplified aerosolization of microorganisms (Meers and Leong, 1989). However, others have recommended that there is small differentiation in aerosolization for the different drying methods (Taylor et al., 2000). Several studies have reported an extent in the numbers of bacteria through drying with paper towels compared with drying with a warm air dryer (Gustafson et al., 2000; Huang et al., 2012; Meers and Yeo, 1978).

Paper towels, hot air dryers, jet air dryers and cloth towels are the most frequently used means of hand drying in public washrooms. Snyder (1998) suggested that air dryers should not be used, as they accumulate aerosols from the toilets and then contaminate hands (Snyder, 1998). He refers to studies where the use of paper towels was shown to decrease the amount of bacteria on hands, while hot-air dryers increased contamination by some bacteria. Whether or not hot air dryers actually are worse than paper towels in this respect is debatable (Holah and Lelieveld, 2011) but what is clear is that hot air dryers are often slow and inefficient, leaving the hands of users moist and possibly still contaminated. Redway and Fawdar (2008) reported a notable increase of bacteria when using hot air dryers compared to when using paper towels; the latter generally led to a decrease in bacterial numbers (Redway and Fawdar, 2008). These authors stated that this is largely due to the fact that hot air dryers do not dry hands as effectively as do paper towels. The same study showed that although air dryers dry the hands as effectively as paper towels, they still increase the number of bacteria on the hands. Cloth roller towels are similarly not recommended essentially because they are low in capacity, and when a roll is finished, it becomes a common-use towel which many people touch and is therefore likely to increase the spread of pathogens (Snyder, 1998). Smith and Lokhorst (2009) refers to a recent study in which European respondents overwhelmingly (96%) considered hand paper towels to be the most hygienic way of hand drying (Smith and Lokhorst, 2009).

This work was assumed with the aim of evaluating the performance of warm air hand driers, in washrooms, in relation to bacterial contamination. First, the ability of warm air driers to dry hands hygienically was evaluated by measuring the number of microorganisms on different working days. Secondly, we determined if warm air driers do in fact alter levels of air-borne microorganisms in the washroom environment, as was suggested (Knights et al., 1993). Finally, the surfaces of warm air driers and other washroom areas were examined for total viable counts in order to determine if the use of air driers alters the distribution of bacteria. The results provide an evidence base for the development and improvement of hygienic hand drying practices.

2. Materials and methods

The fifteen air-dryers in the washroom of an academic institution in the Kingdom of Saudi Arabia were used to assess the bacterial contamination. The air-dryers were turned on for 30 s and the air was played onto nutrient agar medium in the petri dishes. The petri dishes were then incubated at 37 °C for 48 h and after incubation a total count of bacteria

was calculated. Bacterial contamination of the surface was evaluated by placing petri dishes containing nutrient agar medium in a washroom for a period of ten minutes, followed by incubation at 37 °C for 48 h.

2.1. Bacterial isolates and Identification

Identification of bacterial isolates was performed using conventional methods (Murray et al., 2003) including, colonial morphology, culture characteristics on nutrient agar media. The gram staining of the isolates was also studied for identification of gram-positive and gram-negative bacteria to species level using the Vitek2^R Automated Microbiology System.

3. Results and discussion

Hand drying is an essential component of the hand sanitation development, which aims to optimize the removal of potentially pathogenic microorganisms that may be acquired through toileting and making use of bathrooms. The published confirmation regarding whether hand-drying methods may vary in their propensity to aerosolize and so transmit microorganisms is contradictory (Taylor et al., 2000; Ansari et al., 1991; Matthews and Newsom, 1987; Blackmore and Prisk, 1984; Blackmore, 1989; Meers and Leong, 1989). Some studies suggest that drying hands via warmed air is associated with increased aerosolization of microorganisms, and others suggest there to be no difference (Gustafson et al., 2000; Hennessy et al., 2007; Boyce and Pittet, 2002; Anderson et al., 2008; Garbutt et al., 2007). Methodological issues may explain these discrepancies.

The aim of the study was to determine the effect of the use of hand air dryers on microbial contamination of the washroom environment. Nutrient agar plates were exposed for 30 min in order to evaluate total viable counts on three days (Sunday, Thursday and Friday/Saturday). Control and exposure plates involved the same sampling time; therefore, they provide an indication of the contamination level before and after each trial and also indicate how contamination differed between the 3 days.

Table 1; Figs. 1 and 2 show that *Staphylococcus haemolyticus*, *Micrococcus luteus*, *Pseudomonas alcaligenes*, *Bacillus cereus* and *Brevundimonad diminuta/vesicularis* were emitted from all of the dryers sampled, with 95% showing evidence of the presence of the potential pathogen, *Staphylococcus*. The presence of these bacteria in the air flow of such a high proportion of warm air dryers and the increase in the numbers of these bacteria on the hands of the user demonstrate the potential for the spread of food poisoning organisms after

Table 1 Identities of bacteria detected after exposure to air-dryer for 30 s.

Bacteria isolated	Frequency of cfu isolated per sampling air-dryer (%)
<i>Brevundimonad diminuta/vesicularis</i>	3
<i>Staphylococcus haemolyticus</i>	52
<i>Micrococcus luteus</i>	29
<i>Bacillus cereus</i>	4
<i>Pseudomonas alcaligenes</i>	12

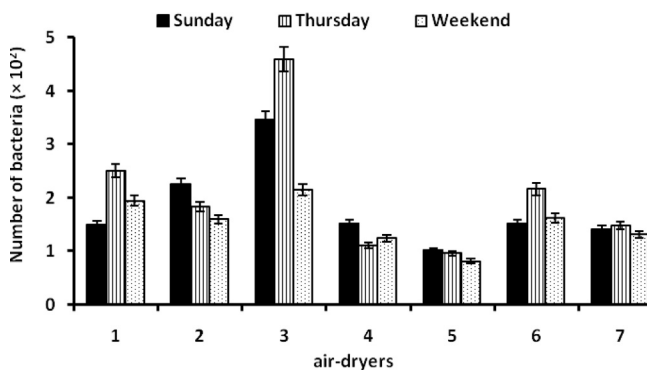


Figure 1 Number of bacteria of air-dryers for 30 s in washrooms at academic institutions.

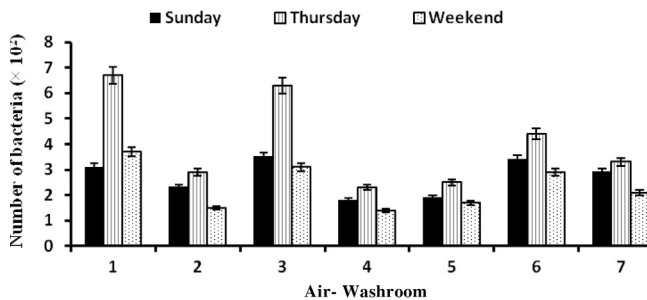


Figure 2 Number of bacteria detected on cm² for 1 h in washrooms at academic institutions.

the use of this method of hand drying. Bacteria were also isolated from the contaminated air of the washroom, with *Staphylococci* and *Micrococci* being blown out of 95% of the air 56% showing evidence of the potential pathogen, *Staphylococcus aureus*, an observation which agrees with the findings (Yamamoto et al., 2005; Taylor et al. 2000).

Few, if any, published reports have considered the passage of bacteria, naturally present on people's hands, to the surrounding environment during the drying process. Campden BRI (unpublished report) have previously conducted a series of experiments to assess the generation and spread of microbial aerosols by different hand-drying techniques. The results from ballistic droplet generation confirm the results obtained previously, where the water droplets generated by the air blade dryer extended to at least 2 m to the sides of the equipment. In other studies, differences were seen between any of the hand-drying techniques investigated, i.e. in regard to microbial aerosol generation, and all the counts produced were very low (maximum 14 cfu per plate). This may be due to a smaller number of volunteers used (5 persons) in the previous studies compared to the described studies (100 persons). Several studies have compared the contamination of the surrounding environment caused by paper towels and hot air dryers (Huang et al., 2012); however, a limited number of studies have focused on hand air dryers. Redway and Fawdar (2008) investigated the spread of artificial contamination via different drying methods and concluded that bacteria were spread significantly further when an air blade dryer was used, compared to paper towels (Redway and Fawdar, 2008). The European Tissue Paper Industry Association (2012) funded

research focused on investigating contamination levels of washrooms with paper towels and air blade dryers installed. The total microbial count on washrooms floors where an air blade dryer was installed was 4.44×10^5 cfu per 100 cm² higher than in the washrooms where paper towels were used. This number is higher than that found in the current study; however, the experimental conditions used were different significantly, with their studies being conducted in the laboratory rather than a real wash-room environment. It was found that both the air blade and paper towel methods produced ballistic droplets when used to dry hands, particularly close to the hand-drying event; these droplets have the potential to carry skin flora, which may contain pathogens. It was found that the ballistic droplet number and distance of travel were slightly higher for the air blade unit.

Overall, the work reported here shows that hand air dryers produce more ballistic droplets which are spread further and may carry bacteria over extensive areas. There was no evidence of any differences between the drying approaches with respect to bacteria carried by non-ballistic aerosols. The study suggests that when selecting a hand-drying method, the risk of cross contamination of bacteria to washroom users and the environment must be considered, and the methods to control this risk must be established.

4. Conclusions

Hot air dryers have the potential for depositing pathogenic bacteria onto the hands and body of users. Bacteria can also be inhaled and distributed into the general environment whenever dryers are running. It is recommended therefore that the use of hot air dryers should be carefully considered on health grounds, especially in sensitive locations such as hospitals, catering establishments and food preparation areas.

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