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Microbiological comparison of hand-drying methods: the potential for contamination of the environment, user, and bystander

E.L. Best [a], P. Parnell [a], M.H. Wilcox [a,b,*]

[a] Microbiology Department, Old Medical School, Leeds General Infirmary, Leeds Teaching Hospitals NHS Trust, Leeds, UK
[b] University of Leeds, Leeds, UK

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SUMMARY

Background: The efficiency of hand drying is important in preventing pathogen spread, but knowledge surrounding which drying methods contribute least towards contamination of the environment and users is limited.

Aim: To compare the propensity of three common hand-drying methods (jet air, warm air dryers, and paper towels) to contaminate the environment, users, and bystanders.

Methods: Hands were coated in lactobacilli to simulate poorly washed, contaminated hands, and dried. The investigation comprised 120 air-sampling tests (60 tests and 60 controls), divided into close and 1 m proximity from the drying process. Separate tests used hands coated in paint to visualize droplet dispersal.

Findings: Air bacterial counts in close proximity to hand drying were 4.5-fold higher for the jet air dryer (70.7 cfu) compared with the warm air dryer (15.7 cfu) ($P = 0.001$), and 27-fold higher compared with use of paper towels (2.6 cfu) ($P < 0.001$). Airborne counts were also significantly different during use of towel drying versus warm air dryer ($P = 0.001$). A similar pattern was seen for bacterial counts at 1 m away. Visualization experiments demonstrated that the jet air dryer caused the most droplet dispersal.

Conclusion: Jet air and warm air dryers result in increased bacterial aerosolization when drying hands. These results suggest that air dryers may be unsuitable for use in healthcare settings, as they may facilitate microbial cross-contamination via airborne dissemination to the environment or bathroom visitors.

Introduction

Hand hygiene is a fundamental component for controlling the spread of infection.[1,2] Promotion of improved hand hygiene is recognized as an important public health measure. There is much emphasis on the correct method for handwashing, but less so concerning the options for drying hands. Evidence suggests that efficiency of hand drying is important in the prevention of the transfer of micro-organisms from person to person or to the environment.[3] However, the risk of aerosolizing micro-organisms during hand drying by various methods remains unclear.

Methods for hand drying vary widely and include paper or cloth towels, warm air dryers or jet air dryers either singly or in

* Corresponding author. Address: Microbiology Department, Old Medical School, Leeds General Infirmary, Leeds Teaching Hospitals NHS Trust, Leeds LS1 3EX, UK. Tel.: +44 113 392 6818; fax: +44 113 392 2696.
E-mail address: mark.wilcox@leedsth.nhs.uk (M.H. Wilcox).

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combination. Drying with towels may remove remaining micro-organisms through friction, while moisture is wicked away into the absorbent material. Warm air dryers evaporate moisture and remove some micro-organisms during hand rubbing, although this process may take too long for efficient use, with hands consequently remaining damp. Newer jet air dryers rely on the passage of high speed, usually unheated, air to dry hands without rubbing, typically in 15 s.[4] The selection of drying method may depend upon a number of factors including practicality, space availability, cost, or personal preference. Infection prevention considerations may influence the choice of hand-drying method, but the evidence base is weak to make informed decisions. Notably, the recent National Health Service (NHS) building guidance states that 'Hot-air hand dryers reduce paper waste and may be considered for use in public areas of healthcare facilities, but should not be installed in clinical areas as they are noisy and could disturb patients'.[5] It is clearly desirable to ensure that the process of hand drying does not increase the potential for micro-organism transmission, either directly to another person or indirectly by contamination of the bathroom environment.

Evidence concerning whether hand-drying methods differ in their propensity to aerosolize, and so transmit micro-organisms, is contradictory.[6–11] Some studies suggest that drying hands with warmed air is associated with increased aerosolization of micro-organisms.[11] However, others have suggested that there is little difference in aerosolization for the different drying methods.[6] One of the reasons for discrepant results may be the use of relatively insensitive methods or experimental designs that fail to detect real differences. In this study, we aimed to compare the propensity of three widely used methods of hand drying (jet air dryer, warm air dryer, and paper towel drying) to contaminate the environment with bacteria via aerosolization during the drying process. Additionally, we investigated the extent of possible contamination of people drying their hands, as well as the possibility of contamination of a bystander.

Methods

Organization of air sampling

All tests were carried out in a room measuring 65 m^3 with the door closed throughout experiments. Room air was maintained by standard ventilation without air-conditioning or negative or positive pressure ventilation. For each test, gloved hands were first coated by immersion in a suspension of lactobacilli (10^7 cfu/mL) that were cultured from a proprietary yoghurt (Actimel®, Danone, Paris, France) and then dried in a standardized manner using one of each of the three drying methods: a warm air dryer, a jet air dryer, or paper towels. In total, this part of the study comprised 120 air-sampling tests (60 tests and 60 controls) with a total testing time of 15 min per test (comprising up to 40 s of drying time dependent on the method used and the remainder being the air-sampling time). The 60 air-sampling tests of contaminated hands comprised 20 collections for each drying method, of which 10 were in close proximity to the hands being dried and 10 were 1 m away. Control air sampling was carried out before every hand-drying test (with no hand drying taking place) both to provide baseline measurements and to minimize the risk of carryover of airborne bacteria. Experiments were carried out over a period of six weeks.

Air-sampling process

Two electric hand dryers, a jet air dryer (Dyson Airblade™) and warm air dryer (Pro-Elec GSQ250B), and a paper towel dispenser (Tork H3 classic dispenser containing Tork Advanced Towels, MRT213) were mounted on one wall at manufacturer-recommended heights for use. Air was collected using two Airtrace Environmental portable samplers (Biotrace, Microbial Contamination Control, Runcorn, UK) via a 1 m long Tygon tube placed at the left- and right-hand sides (LHS, RHS) of each drying unit, in close proximity and also at 1 m away. As air entered the sampler (28.3 L/min), it was forced through a fine slit (44 × 0.152 mm) at a velocity of 70 m/s thereby causing particulate matter (minimum size 0.4 μm) to impact upon a 140 mm diameter, lactobacillus-selective, agar plate (LAMVAB agar, Bioconnections, Wetherby, UK, supplemented with vancomycin). The plate rotated constantly from a known start point throughout the sampling period; thus, following culture, the location of the colonies represents the time of recovery from air. Following each test, the two plates (from the LHS and RHS) were immediately transported to the laboratory and incubated in an anaerobic cabinet at 37°C for 48–72 h, and colonies were then counted. Data from each drying method were compared using Mann–Witney *U*-test (SPSS, IBM, Armonk, NY, USA) using a 5% confidence level to determine significance. In addition, four settle plates containing LAMVAB agar were sited at various locations around each dryer (Figure 1). At the end of each sampling session, the air-sampling machine was cleaned externally and internally using a disinfectant (Trigene, Medichem, Queenborough, UK) and run on a purge cycle to decontaminate the machine and tubing, as recommended by the manufacturer. Floor surfaces, the wall area around the dryers, and the dryer units were also thoroughly cleaned between tests using Trigene.

Testing procedure

Air-sampling tubes were clamped at a height of 1.2 m (from floor level) on the LHS and RHS of the area where the drying of lactobacilli-contaminated gloved hands was taking place, in the outer edges of the airstream produced by the jet and warm air dryers. To ensure reproducibility, this was the same relative position for each of the hand-drying methods. For the tests 1 m away from the hand drying, the ends of the air-sampling tubes were clamped at the same height as before. The air samplers were switched on and hands were then immediately dried. For the warm air dryer, hands were rubbed together for 30–40 s until dry; for the jet air dryer, hands were placed into the unit and slowly drawn up until dry (15 s); for towel drying, four paper towels were taken from the dispenser and these were rubbed over hands until dry (15 s). The air samplers were left running for 15 min following each hand-drying process.

Visual determination of the extent of contamination of the environment, user, and bystander

To visualize the extent of potential contamination occurring during each drying process within the environment, and on to a