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A comparative study of different hand drying methods: paper towel, warm air dryer, jet air dryer.

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The study was completed at the end of last year and was sponsored by the European Tissue Symposium (ETS) Brussels.

It follows on from several other similar studies that the University of Westminster has carried out on hand drying and washroom hygiene since 1993.

The study investigated 3 different hand drying methods and was in 4 parts:

Part A: Drying efficiency.

Part B: Changes in the numbers of bacteria on the hands after drying.

Part C: Potential contamination of other users and the washroom environment.

Part D: Bacterial contamination of jet air dryers in public washrooms.

Part A: Drying efficiency

Method

The amount of water remaining on the hands of subjects after washing and then drying using 5 types of paper towel, a warm air dryer and a jet air dryer was measured as percentage (%) dryness at different times up to 1 minute.

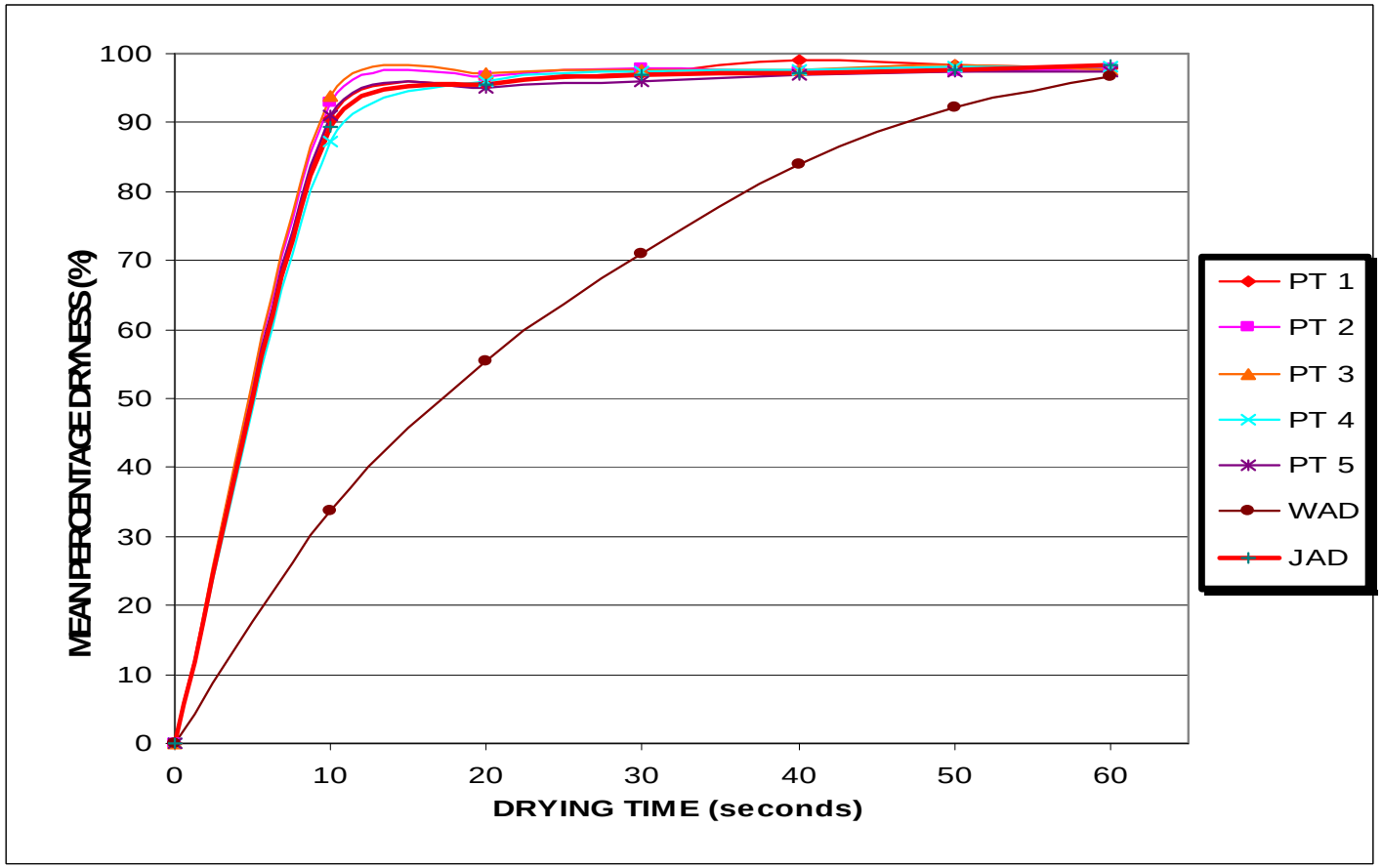
Results for Part A

Table showing the mean times to achieve a minimum of 90% dryness of the hands using 5 different types of paper towel (PT), a warm air dryer (WAD), and a jet air dryer (JAD).

HAND DRYING METHOD	MEAN TIME TO ACHIEVE A MINIMUM OF 90% DRYNESS (seconds)
PT1	10
PT2	10
PT3	10
PT4	11
PT5	10
WAD	47
DAB	10

(N = 2)

Graph of the mean percentage dryness of the hands of subjects against drying time using five different types of paper towel (PT), a warm air dryer (WAD), and a jet air dryer (JAD).



Conclusions for Part A

The results showed that the 5 types of paper towel and the jet air dryer were equally efficient at drying the hands of users, all of them achieving 90% dryness in approximately 10 seconds.

However, the results showed that the warm air dryer was considerably less efficient (*i.e.* slower) than the 5 types of paper towel and also the jet air dryer and took over 4 times as long to achieve 90% dryness of the hands.

Part B: Changes in the numbers of bacteria on the hands after drying.

Method

20 subjects (10 male, 10 female) were used.

3 different agar growth media were used to count and identify the bacteria on the fingertips and the palms before and after washing and drying using 2 types of paper towel, a warm air dryer and a jet air dryer.

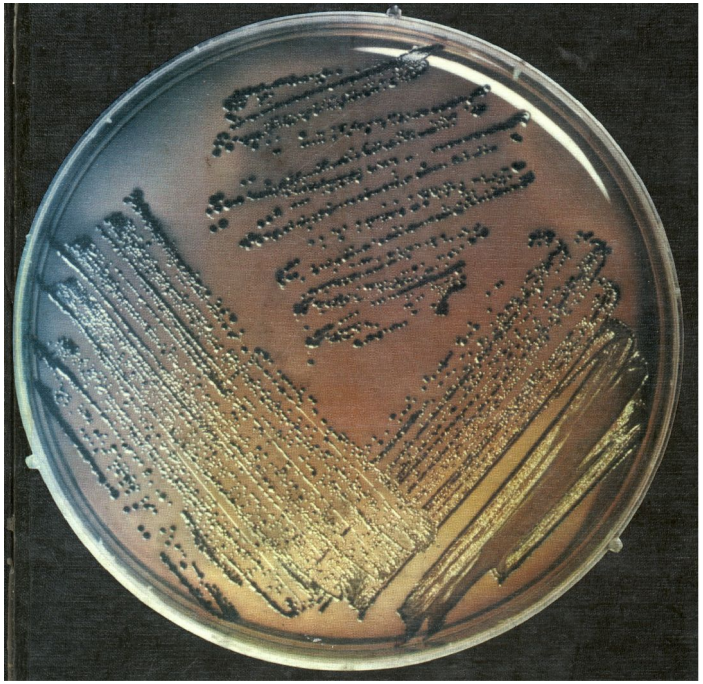
- **Nutrient agar [NA] (grows most types of bacteria but does not usually give their identification)**

- **Cystine-lactose –electrolyte-deficient medium [CLED] (grows gut bacteria and aids their identification, *e.g. E. coli, Salmonella*)**

- **Mannitol salt agar [MSA] (grows skin bacteria and aids their identification, *e.g. MRSA, Staphylococcus aureus*)**

Subjects pressed their fingerpads onto agar plates. Their palms were sampled using a swab and metal ring of set size.

After incubation for 1-2 days bacterial colonies were counted and identified



Bacterial counts performed before and after washing and drying the hands using:

- **Paper towels (PT 1 and PT 3) for 10 seconds**

- **Warm air dryer (WAD) for 20 seconds**

- **Jet air dryer (DAB) for 10 seconds**

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Laboratory set-up showing paper towel dispenser and warm air dryer.

Laboratory set-up showing jet air dryer.

Results for Part B

Summary of mean percentage (%) changes in bacterial numbers on fingerpads before and after washing and drying hands using different hand drying methods.

GROWTH MEDIUM	PAPER TOWEL 1	PAPER TOWEL 2	WARM AIR DRYER	JET AIR DRYER
NA	-45	-77	+186	+53
CLED	-53	-70	+204	+28
MSA	-57	-77	+191	+46
TOTAL (ALL 3 MEDIA)	-51	-76	+194	+42

GREEN FIGURES = REDUCTIONS IN BACTERIAL NUMBERS

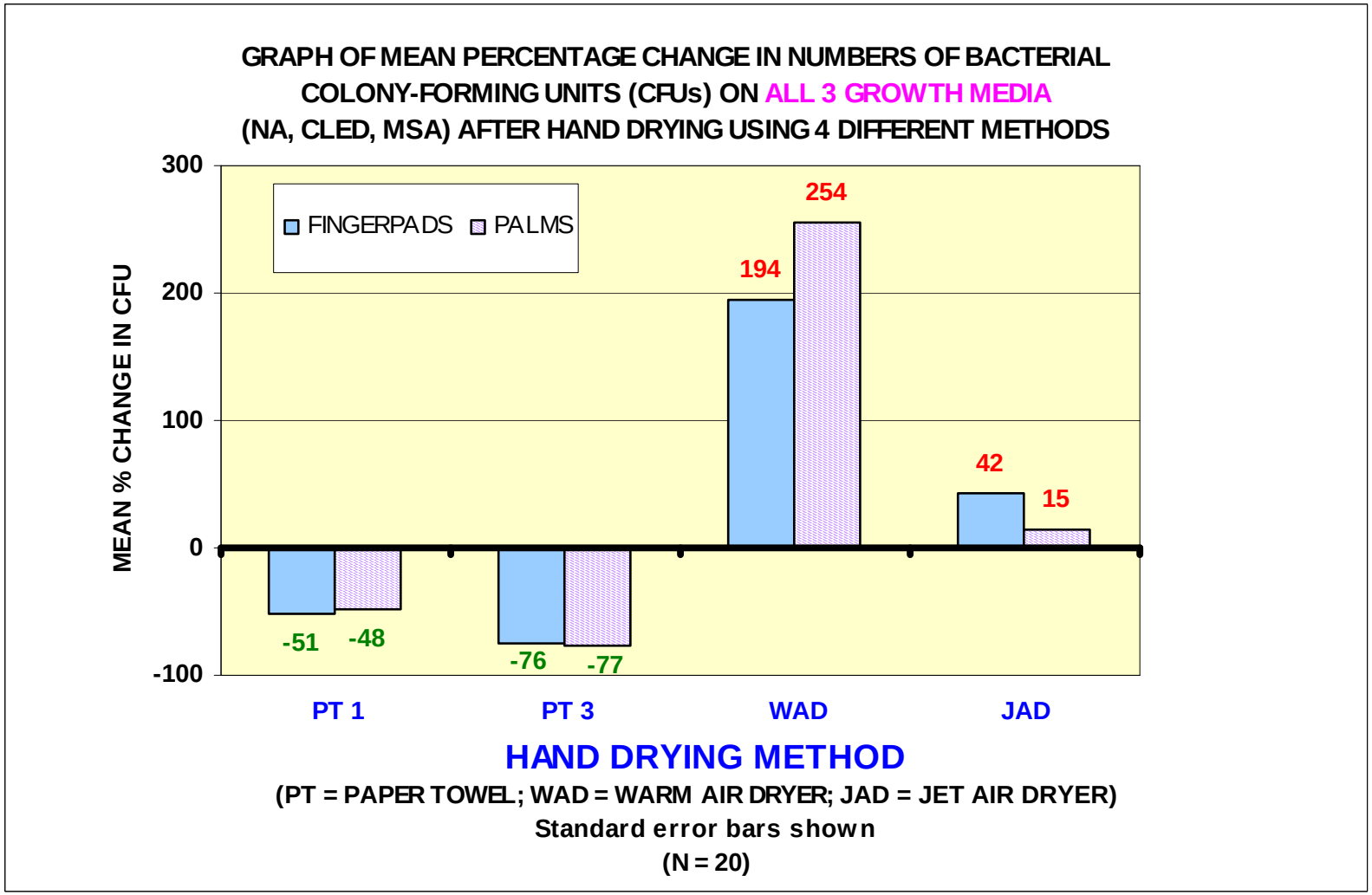
RED FIGURES = INCREASES IN BACTERIAL NUMBERS

Summary of mean percentage (%) changes in bacterial numbers on palms before and after washing and drying hands using different hand drying methods.

GROWTH MEDIUM	PAPER TOWEL 1	PAPER TOWEL 2	WARM AIR DRYER	JET AIR DRYER
NA	-61	-78	+230	+9
CLED	-41	-72	+243	+14
MSA	-35	-81	+303	+23
TOTAL (ALL 3 MEDIA)	-48	-77	+254	+15

GREEN FIGURES = REDUCTIONS IN BACTERIAL NUMBERS

RED FIGURES = INCREASES IN BACTERIAL NUMBERS


GRAPH OF MEAN PERCENTAGE CHANGE IN NUMBERS OF BACTERIAL COLONY-FORMING UNITS (CFUs) ON ALL 3 GROWTH MEDIA (NA, CLED, MSA) AFTER HAND DRYING USING 4 DIFFERENT METHODS
MEAN % CHANGE IN CFU
300
200
100
0
-100
FINGERPADS
PALMS
-51
-48
-76
-77
194
254
42
15
PT 1
PT 3
WAD
JAD
HAND DRYING METHOD
(PT = PAPER TOWEL; WAD = WARM AIR DRYER; JAD = JET AIR DRYER)
Standard error bars shown
(N = 20)

Conclusions for Part B

Both types of paper towel (PT 1 & PT 3) reduced the numbers of all types of bacteria on both the fingerpads and the palms of subjects.

The warm air dryer increased the numbers of all types of bacteria on both the fingerpads and the palms of subjects.

The jet air dryer increased the numbers of most types of bacteria on both the fingerpads and the palms of subjects.

Part C: Potential contamination of other users and the washroom environment.

Method

The hands of 10 subjects were artificially contaminated with yeast suspension.

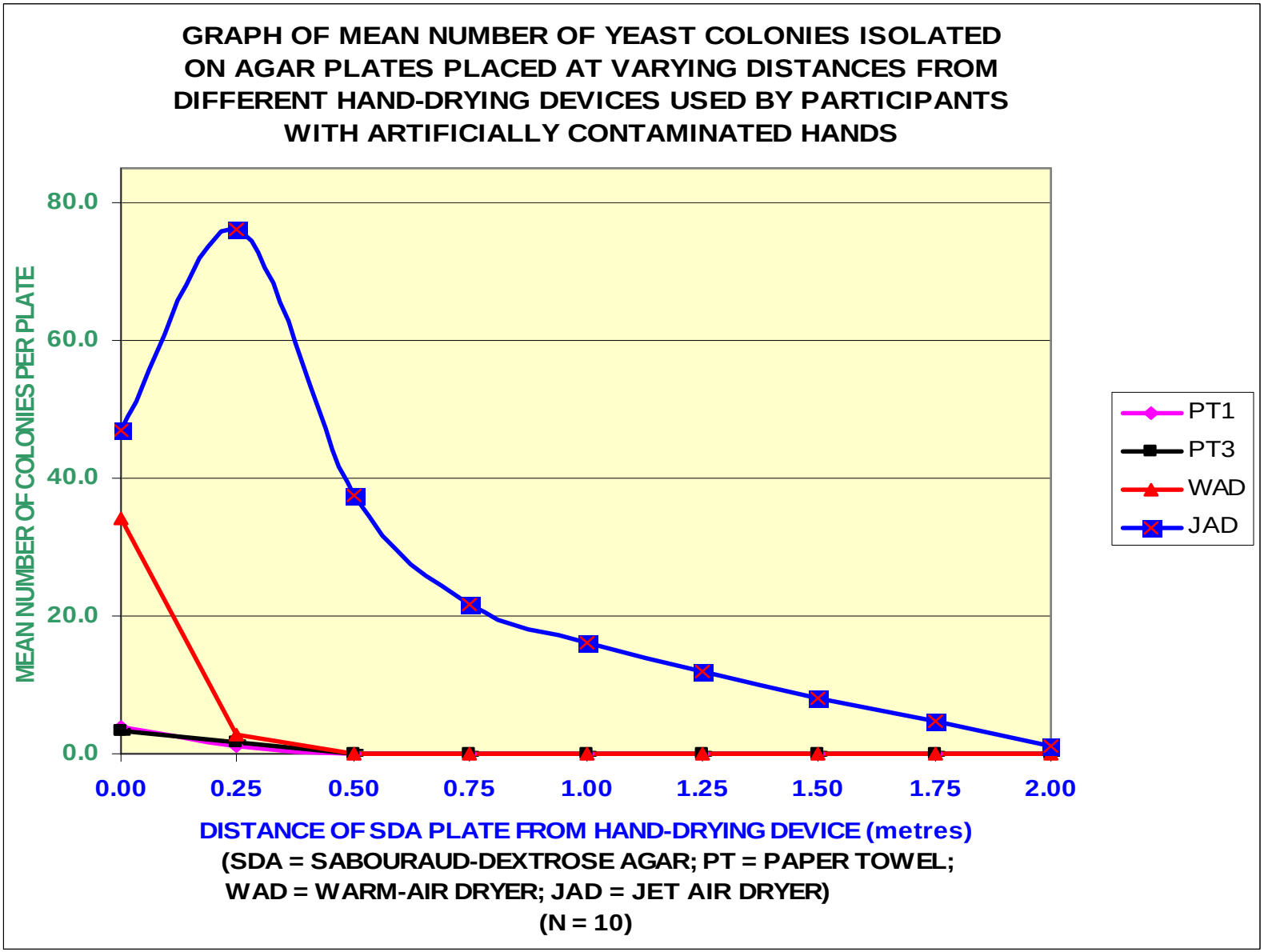
The subjects then dried their hands using 2 types of paper towel (10 seconds) or a warm air dryer (20 seconds) or a jet air dryer (10 seconds).

During use open agar plates were placed at 0.25 metre intervals from the hand drying device up to a maximum of 2 metres. Yeast colonies that grew on the plates were counted.

Results for Part C

Mean number of yeast colonies isolated on agar plates placed at varying distances from different hand-drying devices used by subjects with artificially contaminated hands.

HAND DRYING DEVICE	DISTANCE OF AGAR PLATE FROM DEVICE (metres)								
	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
PAPER TOWEL 1	4.0	1.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
PAPER TOWEL 3	3.2	1.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WARM AIR DRYER	34.1	2.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0
JET AIR DRYER	47.0	76.2	37.5	21.8	16.0	11.9	8.1	4.8	1.2


GRAPH OF MEAN NUMBER OF YEAST COLONIES ISOLATED ON AGAR PLATES PLACED AT VARYING DISTANCES FROM DIFFERENT HAND-DRYING DEVICES USED BY PARTICIPANTS WITH ARTIFICIALLY CONTAMINATED HANDS
MEAN NUMBER OF COLONIES PER PLATE
80.0
60.0
40.0
20.0
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
PT1
PT3
WAD
JAD
DISTANCE OF SDA PLATE FROM HAND-DRYING DEVICE (metres)
(SDA = SABOURAUD-DEXTROSE AGAR; PT = PAPER TOWEL;
WAD = WARM-AIR DRYER; JAD = JET AIR DRYER)
(N = 10)

Conclusions for Part C

The jet air dryer can disperse potential contamination to other users and the washroom environment to a distance of at least 2 metres.

Warm air dryers and paper towels do not disperse potential contamination as much as the jet air dryer.

Warm air dryer performs worse than paper towel directly below the device but there is little significant difference at greater distances.

The distances between jet air dryers in pairs in the male and female washrooms of a mainline London railway station ranged from 0.36 to 0.45 metres, with an average distance of 0.39 metres.

Jet air dryers in a gents washroom.

A pair of jet air dryers in a gents washroom.

Part D: Bacterial contamination of jet air dryers in public washrooms.

Method

Sterile swabs were used to sample the inner surfaces of 8 jet air dryers in the gents washroom and 8 in the ladies washroom of a main line London rail station on different days and at different times.

One swab sample was taken from each dryer by swabbing the inner surfaces and the air slits. Another swab sample was taken along the bottom of the hand drying chamber.

Samples of the air emitted for 10 seconds by the jet air dryers were taken using open agar plates of 3 the different growth media as used in Part B.

Swab samples were plated out on agar plates, incubated, and the numbers of colonies recorded and identified.

Results for Part D

Mean bacterial colony counts on different growth media of samples from jet air dryers in public washrooms.

SAMPLE TYPE	GROWTH MEDIUM		
	NUTRIENT AGAR	CLED	MANNITOL SALT AGAR
INNER SURFACES AND SLITS PER cm^2	171	85	127
BOTTOM OF DRYING CHAMBER PER cm^2	7003	7537	4745
10-SECOND AIR SAMPLE PER AGAR PLATE	14	20	10

Bacteria isolated from jet air dryers in public washrooms included:

BACTERIUM	SOURCE	PERCENTAGE (%) OF POSITIVE SAMPLES	CAN CAUSE
E. coli	Human gut and faeces	23	Urinary tract infections
Klebsiella species		10	Pneumonia
Staphylococcus aureus	Human skin, hair and nose	71	Boils, abscesses, food poisoning, *etc.*
Other *Staphylococcus* species		94	Urinary tract and other infections
Pseudomonas aeruginosa	Water and soil	21	Wound and lung infections

Conclusions for Part D

The jet air dryers sampled in these public washrooms were contaminated with large numbers of bacteria.

Bacteria were detected on the inner surfaces and in the air emitted by the jet air dryers.

The greatest numbers of bacteria were found at the bottom of the hand drying chamber.

Some of the bacteria were potential pathogens (*i.e.* could cause disease).

Overall conclusions

Part A showed that the jet air dryer was equally efficient as the paper towel at drying the hands and both were considerably more efficient than the warm air dryer.

Part B showed that paper towel reduced the mean numbers of all types of bacteria on the fingerpads and palms of the hands.

The warm air dryer and jet air dryer both increased the mean numbers of most types of bacteria on the fingerpads and palms, with the warm air dryer producing the largest increases.

Part C showed that paper towel is likely to produce considerably less contamination of other users and the washroom environment than the jet air dryer.

Part D showed that the jet air dryers in the public washrooms sampled were contaminated with large numbers of bacteria, particularly the bottom of the hand drying chamber.

Some of the bacteria isolated from jet air dryers in the public washrooms were potential pathogens (*i.e.* could cause disease).

Summary of dryer characteristics

CHARACTERISTIC	PAPER TOWEL	WARM AIR DRYER	JET AIR DRYER
DRYING EFFICIENCY (SPEED OF DRYING)	HIGH (FAST)	LOW (SLOW)	HIGH (FAST)
AVERAGE CHANGE IN BACTERIAL NUMBERS ON THE HANDS AFTER USE	REDUCTIONS	INCREASES	INCREASES
POTENTIAL FOR CONTAMINATION OF OTHER USERS AND THE WASHROOM	VERY LOW	LOW	HIGH
NUMBERS OF PATHOGENIC BACTERIA CONTAMINATING THE DEVICE OR TOWEL	NONE	HIGH *	HIGH

* NOT TESTED IN THIS STUDY
(but has been in previous UoW studies)

In all the tests in this study, paper towel was found to be superior to both types of electric dryer, with the exception of hand drying efficiency and speed where the jet air was equal to paper towel, but the warm air dryer never was.

Based on these results, the use of warm air dryers and jet air dryers should be carefully considered in locations where hygiene is paramount, such as hospitals, clinics, schools, nurseries, care homes, kitchens and other food preparation areas.

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