The importance of hand drying:
Factors in choosing a suitable method
Pathogens love hands. In a single day, we come into contact with countless contaminated surfaces, especially those we touch frequently, like our keyboards and our phones.

Those surfaces can act as reservoirs for infectious organisms ready to be passed on to someone else. And hands provide the ideal mode of transport.

By preventing the spread of bacteria, good hand hygiene can help protect against infections in shared spaces like offices and retail, and crucially in residential care and healthcare facilities. Think about how many signs and notices you see in hospitals reminding you to wash your hands. This is a deliberate strategy to prevent the spread of pathogens: indeed, the World Health Organisation produced its ‘Five Moments for Hand Hygiene’ strategy that prescribes the when’s and how’s of good hand hygiene practice. Naturally, the food industry also places a lot of importance on hand hygiene. Hands play a major role in cross-contamination (transferring bacteria from hands to foods or from raw food to hands) and good hand hygiene is one of the most effective ways to prevent gastro-intestinal diseases. But hand drying for all sectors is also an important consideration, and an important part of making sure that hands are properly fit for purpose (Michaels et al., 2004).

So, this has turned the focus to different methods of hand drying as part of a good hand hygiene regime. Unfortunately, the advice here is often difficult to decipher and contradictory. As Table 1 shows, there are a number of different provisions that fit under the banner of ‘hand drying’. The aim of this whitepaper is to evaluate the advantages and disadvantages of these different drying methods to help bring clarity to this question.

Table 1. United States Food Code 2013

<table>
<thead>
<tr>
<th>Hand drying provision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each handwashing sink or group of handwashing sinks shall be provided with:</td>
</tr>
<tr>
<td>A. Individual, disposal towels;</td>
</tr>
<tr>
<td>B. A continuous towel system that supplies the super with a clean towel, or</td>
</tr>
<tr>
<td>C. A heated air hand drying device; or</td>
</tr>
<tr>
<td>D. A hand drying device that employs an air-knife system that delivers high velocity,</td>
</tr>
<tr>
<td>pressurized air at ambient temperatures.</td>
</tr>
</tbody>
</table>

“Hand drying is an important part of a good hand hygiene regime”
Reasons for hand drying and why it is important

1. **For comfort**
   
   After people wash and rinse their hands, the natural reaction is to want to dry them. Studies have found that although 70% of consumers valued hand drying, almost 1.5% used their own clothing to dry their hands. But this problematic method of drying needs to be avoided: clothes are not necessarily clean and aprons/protective wear can be contaminated with raw foods.

2. **Removing soil, microorganisms and moisture**
   
   Not only can hand drying remove dirt from hands and make them feel cleaner but it can also remove microorganisms from the skin surface which comes from hand washing. Drying can also prevent them from being re-deposited back onto the skin. Previous studies have found that wet hands can present a greater risk of microbial cross contamination (Michaels et al., 2004; Merry et al., 2001; Tuladhar et al., 2013; Conover and Gibson, 2016). Another study found the threat of microbial transfer could be 1,000 times greater from wet hands than from dry hands.

3. **Hand drying can reduce the impact of poor hand washing**
   
   This depends on how the experiment was conducted, and which method of hand drying is being used (see Table 4 for hand drying methods), but typically after handling foods, hand drying alone can achieve a one log reduction in the number of microorganisms present. It also enhances the efficacy of hand washing and can lead to a reduction in the risk of food contamination (Michaels et al., 2004).

Difficulties selecting a method for hand drying

Previous studies have discussed the advantages of the different hand drying methods, however, most of the time they reach different conclusions.

This tends to happen because of:

1. **How the experiment was designed**
   
   How a hand drying test is designed and performed can influence the results. Results from the area of the hands tested will also reach a different evaluation – for example, some experiments may test the whole hand, when others just test the finger tips/pads. Whilst many studies claim one method is more effective than others (see Table 2) the results may not be comparable. Experiments conducted on air dryers can also reveal different results depending on how old or new the hand dryer is.

2. **The relative importance of the different factors assessed**
   
   Every industry has a primary focus. In healthcare, the risk of dispersing microorganisms into a washroom atmosphere is a great concern. This would be less of a concern for a small office business, for example. Fundamentally, the ideal choice of drying method will depend on the organisation’s needs, circumstances and individual requirements.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Year</th>
<th>Type of paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huang et al., 2012</td>
<td>2012</td>
<td>Review</td>
</tr>
<tr>
<td>Snelling et al., 2010</td>
<td>2010</td>
<td>Experimental</td>
</tr>
<tr>
<td>Yamamoto et al., 2010</td>
<td>2010</td>
<td>Experimental</td>
</tr>
<tr>
<td>Gustafson et al., 2000</td>
<td>2000</td>
<td>Experimental</td>
</tr>
<tr>
<td>Kimmitt and Redway, 2015</td>
<td>2015</td>
<td>Experimental</td>
</tr>
</tbody>
</table>
What affects drying efficiency?

Table 3 demonstrates some of the experimental variables that can affect the results of both hand washing and hand drying:

**Table 3. Experimental variables affecting drying efficiency results**

<table>
<thead>
<tr>
<th>Test organism</th>
<th>Organism (bacteria, virus, fungus) or strain (type, laboratory or wild type)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temporary or resident flora</td>
</tr>
<tr>
<td></td>
<td>Level of inoculum</td>
</tr>
<tr>
<td></td>
<td>Method of hand inoculation</td>
</tr>
<tr>
<td></td>
<td>Method of microbial recovery</td>
</tr>
<tr>
<td></td>
<td>Area of hand tested</td>
</tr>
<tr>
<td>Soil</td>
<td>Types of soil</td>
</tr>
<tr>
<td></td>
<td>Extent of soil remaining on hand</td>
</tr>
<tr>
<td>Paper towels</td>
<td>Softness/roughness</td>
</tr>
<tr>
<td></td>
<td>Method of dispensing</td>
</tr>
<tr>
<td></td>
<td>Equipment used in dispensing</td>
</tr>
<tr>
<td>Cloth towels*</td>
<td>Softness/roughness</td>
</tr>
<tr>
<td></td>
<td>Equipment used in dispensing</td>
</tr>
<tr>
<td>Air dryers</td>
<td>Type and make</td>
</tr>
<tr>
<td></td>
<td>Age and condition</td>
</tr>
<tr>
<td></td>
<td>Design and construction</td>
</tr>
<tr>
<td>Natural or artificial setting (in a washroom or in a laboratory)</td>
<td></td>
</tr>
<tr>
<td>Gloved or bare hands</td>
<td></td>
</tr>
<tr>
<td>Drying method</td>
<td></td>
</tr>
<tr>
<td>Speed/duration/extent of drying time (set or variable) or number of towels used</td>
<td></td>
</tr>
</tbody>
</table>

“Damp hands transfer 1000 times more microbes than dry hands”
Methods of drying and what it means

When deciding on a hand drying method, different industries will have different considerations, depending on the sector and what they are most focused on. For example, a business that places more importance on consumer preference, may opt for a solution that is easy to use, quick and emits little noise.

That said, someone in the food / health industry should be more concerned with minimising contamination, and therefore will be interested in drying methods that are effective in removing micro-organisms from the hands.

Table 4. Summary review of the different claims made about hand drying methods

<table>
<thead>
<tr>
<th>Method of drying</th>
<th>Paper</th>
<th>Cloth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ability to remove bacteria/moisture</strong></td>
<td>Generally considered to be one of the most effective drying methods. Thought to be especially effective in removing microorganisms from fingertips.</td>
<td>Generally considered one of the most effective drying methods. One study found it to be the most effective. Relatively quick in reducing hand contamination – study suggests 96% reduction in moisture in 10 seconds, 99% reduction in 15 seconds.</td>
</tr>
<tr>
<td><strong>Compliance and usage consideration</strong></td>
<td>Relatively quick in reducing hand moisture contamination, thought to contribute to higher levels of compliance and consumer preferred choice for drying.</td>
<td>Not consumers’ first choice but perceived to be kindest to hands, cause less tissue damage and be more environmentally friendly than paper towels.</td>
</tr>
<tr>
<td><strong>Hand contamination/recontamination potential</strong></td>
<td>If poorly designed, some paper towel dispensers can show low levels of microbial contamination. Paper towels left unprotected on washroom surfaces are most likely to be contaminated. Some paper towels can be contaminated especially with spore-forming organisms (testing did not distinguish if contaminants were vegetative organisms or dormant spores). Paper towels from recycled materials had higher intrinsic contamination levels. Used contaminated paper towels need to be disposed of in pedal operated/no hand contact bins.</td>
<td>Correctly used carry little hand re-contamination potential. The exception is at end of the roll if the same towel piece is used communally. The end of the roll is always reached and management required to monitor when this is likely to occur.</td>
</tr>
<tr>
<td><strong>Contamination of the atmosphere and environment</strong></td>
<td>Poorly disposed of paper towels could present a re-contamination risk.</td>
<td>Generally considered least likely to contaminate the environment.</td>
</tr>
<tr>
<td><strong>Green credentials</strong></td>
<td>Considered to be more harmful to the environment than air dryers. However in making this assumption evaluations may fail to consider carbon dioxide uptake and oxygen production by trees. Depending on region and paper type the towels may not be recyclable.</td>
<td>Considered to be better for the environment than paper towels.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Warm air dryer</th>
<th>Jet blade</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ability to remove bacteria/moisture</strong></td>
<td>Conflicting results (due to different experimental design and different risks) but generally considered less effective than paper/cloth towels or jet blade dryers in removing moisture and microorganisms. Many studies found the number of hand microorganisms increased after drying. Conflicting opinions on the value of rubbing when drying: Incorporation of UV light into dryer may be beneficial.</td>
</tr>
<tr>
<td><strong>Compliance and usage consideration</strong></td>
<td>Considerable variability but generally considered slowest to remove moisture, some taking up to 40 seconds. In reality one study showed consumers only use for 13-17 seconds. Not consumers’ first choice.</td>
</tr>
<tr>
<td><strong>Hand contamination/recontamination potential</strong></td>
<td>Need to be regularly cleaned and maintained. Some studies show high microbial counts in internal dust/debris and in the air leaving the nozzle. Regular maintenance is required.</td>
</tr>
<tr>
<td><strong>Contamination of the atmosphere and environment</strong></td>
<td>Number of studies indicate risk of environmental and atmospheric contamination. Atmospheric contamination mainly downwards but convection currents can be set up. Considered unsuitable for critical care areas e.g. healthcare and food.</td>
</tr>
<tr>
<td><strong>Green credentials</strong></td>
<td>Considered to be better for the environment than paper towels.</td>
</tr>
</tbody>
</table>

“The right type of hand drying method will be based on a number of factors depending on the business and its sector.”
Comparisons: Wiping

The benefits of wiping hands with cloth (linen/cotton) and paper towels have been known for many years, particularly when it comes to removing soil, moisture and microbes from the skin surface.

PAPER TOWELS

Advantages

Paper towels produce minimal contamination and are typically a user favourite because they’re so expedient and easy to use. They are generally considered the most effective and quick when removing moisture and microorganisms from the skin. For businesses, one of the biggest advantages is that this method of drying is cheaper to install and copes well with high user usage.

Disadvantages

Paper towels are considered to cause environmental harm. However, previous studies claimed the life cycle impact assessments did not consider the beneficial effect of growing trees to provide the towels initially. Studies have also proved paper towels can be already contaminated before use, but this research has never been linked to any infection risks.

Best practice usage

In best practice usage, a receptacle should be available to store the used and dispensed towels. This is due to previous studies demonstrating that paper towels become contaminated during use. All washrooms require supervision and this hand drying method requires management, as well as waste bins being re-filled and emptied regularly.

CLOTH TOWELS

Advantages

Cloth towels are generally considered one of the most effective drying methods with research indicating that ten seconds of drying with a cloth towel was equivalent to 45 seconds of hot air drying. Cloth towels also contaminate the washroom environment the least and carry the lowest risk of hand recontamination. Cloth towels exceed the EU standard and are considered more environmentally friendly than paper towels.

Disadvantages

There has been some inconsistency in the evidence, as some research has found the ability of cloth towels to remove bacteria as less efficient than paper towels. Overall, it is likely there is little to no difference.

Best practice usage

Further care needs to be taken into consideration to ensure replacement of an entire roll when it has been used.
The importance of hand drying and choosing a suitable method

Comparisons: Air drying

**WARM AIR DRYERS**

**Advantages**
Warm air dryers work by removing moisture from the skin by evaporation. They can last up to ten years and are more environmentally friendly than paper towels.

**Disadvantages**
Studies have found that warm air dryers are at risk for contaminating the environment and atmosphere. Therefore, this type of drying method would be considered unsuitable for critical areas such as the healthcare and food industry. Another study found users to only use a warm air dryer on average from 13-17 seconds, resulting them not drying their hands properly.

Rubbing hands together under the dryer can increase hand microbial contamination. Blowing germs into the face of the user, as well as older models which require hand contact with a push of a button, can result in pathogens being passed on to other surfaces and people.

**Best practice usage**
Warm air dryers need to be regularly cleaned and maintained to prevent the spread of pathogens.

**JET BLADE DRYERS**

**Advantages**
Undeniably jet blade dryers are quicker than other types of warm air dryers. Studies found them as effective in removing moisture as paper towels compared to warm air dryers. Jet blade dryers are also considered to be better for the environment than paper towels.

**Disadvantages**
Research has found jet blade dryers can become contaminated with bacteria from water which can pool in the internal base. This can lead to a 2 log (99%) higher surface count than experimental controls. They can also contaminate the atmosphere more than conventional air dryers (up to 2m away from the dryer) which can lead to contamination of other washroom surfaces. In fact, risk of contamination may be 60x greater than air dryers and 1300x more than paper towels, as demonstrated on Table 4.

**Best practice usage**
Jet blade dryers are less likely to be vandalised and may even be more eco-friendly due to lower CO₂ emissions.
The importance of hand drying and choosing a suitable method

Hand drying not only plays a pivotal role in ensuring that people are removing dirt, microorganisms and moisture from their hands, but also reduces the impact of poor hand washing techniques, leaving people feeling cleaner.

Although it can be challenging to find a hand drying method to suit every organisation’s needs, the ideal method is one that follows the seven below requirements:

1. Widely preferred and accepted by users from different industries
2. Energy efficient
3. Reduces the maximum amount of moisture and microorganisms from the hands
4. Does not lead to environmental or hand contamination
5. Can cope with high throughput and peaks in demand
6. Effective and quick to use
7. Cheap to install and run

No individual hand drying method fulfils all of the requirements on Table 5. For example, whilst paper and cloth towels are labelled as “Good” under the ability to remove bacteria, they are also labelled as “Moderate” or “Poor” when it came to green credentials.

Hand drying manufacturers of all types are continuously working on ways to improve their products to help minimise wet hands touching surfaces and the use of equipment which requires no touch.

Fundamentally, the method to choose depends on the priorities of the organisation. Industries in food and healthcare where the priorities lie around the risk of cross-contamination, the removal of moisture and microorganisms, then a paper/cloth method is the best solution. These also apply in public washrooms during times of flu or norovirus epidemics.

Cost comparisons are difficult due to a wide variety of energy and other consumable prices, as well as usage patterns and demand. In this case, if economic consideration (including initial and ongoing costs) is the overriding priority, most comparisons would suggest an air dryer would be the cheaper solution, which is why they are often provided in public washrooms. Overall, it is important to dry hands thoroughly after hand washing, as it is a vital part of reducing cross-contamination and infection risks.

Table 5. Summary review of the different claims made about hand drying methods

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Paper towel</th>
<th>Cloth towel</th>
<th>Warm air dryer</th>
<th>Jet blade dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to remove bacteria</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Residual moisture</td>
<td>Good</td>
<td>Good</td>
<td>Moderate</td>
<td>Poor</td>
</tr>
<tr>
<td>Minimal risk of hand contamination</td>
<td>Moderate</td>
<td>Good</td>
<td>Moderate</td>
<td>Poor</td>
</tr>
<tr>
<td>Minimal risk of environmental contamination</td>
<td>Moderate</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Consumer preference (hence likely compliance)</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
<td>Moderate</td>
</tr>
<tr>
<td>Optimal green credentials</td>
<td>Poor</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Good</td>
</tr>
<tr>
<td>Speed of use by consumer</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Ability to deal with high throughput</td>
<td>Good</td>
<td>Moderate</td>
<td>Poor</td>
<td>Moderate</td>
</tr>
<tr>
<td>Overall cost</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

“Drying hands is vital to reducing cross contamination and infection risks”
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Intermetra (2008) “Study of the consumers’ attitudes to different hand drying systems for European Tissue Symposium”. Intermetra, Unit 1003, 801, Rino Broo.


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