HANDWASHING AND DRYING DURATION – EVIDENCE FOR EFFICACY

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HANDWASHING AND DRYING DURATION – EVIDENCE FOR EFFICACY

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SUMMARY

Hand hygiene is considered to be a key component of infectious disease control. The New Zealand Food Safety Authority and the Ministry of Health recommend that handwashing is carried out according to the '20+20 rule'. This involves washing of hands for 20 seconds with soap and hot water and drying for 20 seconds with a clean, dry towel or paper towel.

For handwashing, there is some evidence to suggest that washing times in excess of one minute provide little or no extra benefit with respect to removal of transient microorganisms. In some cases evidence suggests no additional benefit in handwashing durations greater than 10-15 seconds.

Handwashing for a duration of 30 seconds has been shown to result in a decrease in microbial counts of the order of two log units for a range of organisms artificially applied to hands. However, there is little evidence to suggest an optimum duration of handwashing in the range 10-60 seconds.

There is even less evidence to support guidelines for the duration of hand drying. While some studies suggest superior microbial removal with one method or other, in general no significant differences have been observed. Achieving fully dry hands appears to be important and studies suggest that this will be achieved in a shorter time frame by the use of towels (paper or cloth) than hot air dryers.

1 INTRODUCTION

Hand hygiene has been considered to be a key component of infectious disease control since 1846, when Semmelweis noted a reduction in deaths due to puerperal fever following implementation of hand hygiene protocols. Hand hygiene has been demonstrated to result in reductions in gastrointestinal disease of 30-50% in community settings (Aiello *et al.*, 2008; Curtis and Cairncross, 2003; Ejemot *et al.*, 2008).

1.1 Definitions

Hand hygiene is primarily concerned with the removal or destruction of potentially pathogenic microorganisms. Hand hygiene can be subdivided into two processes:

- Handwashing is the removal of soil and transient micro-organisms from the hands (Larson, 1995); and
- Hand antisepsis is the removal and destruction of transient micro-organisms (Larson, 1995) and includes the use of antimicrobial agents. Antimicrobial agents may be in the form of washes or rubs.

Skin microflora can be categorised into two types – resident and transient (Guzewich and Ross, 1999). Resident bacteria normally exist on the skin and are not easily removed by mechanical friction, as they inhabit the pores where they are protected by sebaceous gland secretions (Jumaa, 2005; Miller *et al.*, 1994). The resident bacteria are predominantly (>90%) coagulase-negative staphylococci and *Corynebacterium* spp. (Miller *et al.*, 1994). The resident skin bacterial population includes only one pathogen of food safety concern, *Staphylococcus aureus* (Guzewich and Ross, 1999; Miller *et al.*, 1994).

Transient microorganisms can be considered to be skin contaminants that derive from environmental sources and become attached to the superficial skin layers (Guzewich and Ross, 1999). Unlike resident bacteria, transient organisms can be readily transmitted by the hands unless removed by hand hygiene procedures. However, they are also easier to remove by hand hygiene procedures than the resident microflora. Viruses are not considered to be normal skin microflora and are included in the transient microorganisms (Jumaa, 2005).

1.2 New Zealand Recommendations

The New Zealand Food Safety Authority and the Ministry of Health recommend that handwashing is carried out according to the '20+20 rule'. This involves washing of hands for 20 seconds with soap and hot water and drying for 20 seconds with a clean, dry towel or paper towel. Information on these handwashing recommendations can be found at: http://www.nzfsa.govt.nz/publications/media-releases/2008/2008-10-15-global-handwashing-day.htm and http://www.nzfsa.govt.nz/publications/food-focus/2008-02/page-13.htm

A recent New Zealand observational study suggests that actual practice fall well short of this recommendation and reported a mean handwashing duration for 1039 subjects of 10.1 seconds (Garbutt *et al.*, 2007). Another unpublished New Zealand study reported even shorter mean handwashing times of 4.4 and 2.7 seconds for females and males respectively on a university campus, 6.4 and 4.3 seconds for females and males in a shopping mall, and

5.3 seconds for both females and males in a healthcare setting (Patrick and Miller, Unpublished).

For the remainder of this document, handwashing will refer to hand hygiene processes employing unmedicated/non-antimicrobial soap.

2 INTERNATIONAL HANDWASHING RECOMMENDATIONS

A number of governmental and professional organisations have made recommendations for handwashing procedures. Guidelines or recommendations generally contain some or all of the following components:

- Removal of rings, watches, etc;
- Wetting of hands;
- Dispensing of soap/detergent;
- Rubbing to create friction (washing). May include special attention to the fingernails;
- Rinsing of hands under running water; and
- Drying of hands

The current study is interested in the evidence base for the '20+20' rule and attention will focus on guidelines for the duration of washing and drying. Details of washing and drying protocols recommended internationally are given in Table 1.

Table 1: International handwashing recommendations

Country/organisation	Handwashing	Hand drying	Reference
Australia/ National Health and Medical Research Council*	Vigorously rub hands together for at least 10-15 seconds	Pat hands dry with disposable paper towel	(National Health and Medical Research Council, 1996)
Canada/ Health Canada	Minimum 10 seconds, more time may be required if hands are visibly soiled	Avoid reusable towels	(Health Canada, 1998)
UK/ EPIC	Rub vigorously for a minimum of 10-15 seconds	Dry with good quality paper towels	(Pratt *et al.*, 2007)
USA/Association for Professionals in Infection Control and Epidemiology	Soap or detergent for at least 10-15 seconds	Discussed, but no recommendation	(Larson, 1995)
USA/ Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force	Soap for at least 15 seconds	Dry thoroughly with a disposable towel	(Boyce and Pittet, 2002)
USA/ Food and Drug Administration	Rub vigorously for 10-15 seconds (cleaning time of at least 20 seconds)	Dry thoroughly using individual disposable towels, a continuous towel system or a heated-air hand drying device	(United States Food and Drug Administration, 2005)

* These guidelines have subsequently been rescinded

It should be noted that of the guidelines in Table 1, only the guidelines from the US Food and Drug Administration are particular to food handling.

Recommended durations for handwashing fall within a reasonably consistent range for soap rubbing of 10-15 seconds. This is shorter than the 20 seconds recommended in New Zealand. None of the guidelines listed in Table 1 make quantitative recommendations with respect to hand drying, which is also at odds with the recommendation in New Zealand of drying for 20 seconds.

A recent US Centers for Disease Control and Prevention (CDC) web page recommends a 20 second wash time. However, the basis for this recommendation is not given. See: http://www.cdc.gov/cleanhands/

A review of international hand hygiene guidelines noted that most recommendations are based, at least partly, on expert opinion, rather than scientific studies (Wendt, 2001). It was also noted that where two different sets of guidelines based a particular recommendation on scientific studies, they offered contradictory recommendations. A systematic review series to support evidence-based guidelines for preventing healthcare-associated infections noted the paucity and methodological limitations of studies on hand decontamination techniques (Pratt *et al.*, 2001; Pratt *et al.*, 2007). It was concluded that "recommendations continue to be based on existing expert opinion that the duration of hand decontamination, the exposure of all aspects of the hands and wrists to the preparation being used, the use of vigorous rubbing to create friction, thorough rinsing in the case of handwashing, and ensuring that hands are completely dry are key factors in effective hand hygiene" (Pratt *et al.*, 2007).

3 DURATION OF HANDWASHING

Determination of the efficacy of hand hygiene measures, including handwashing with unmedicated soap has been shown to depend on a number of factors (Sickbert-Bennett *et al.*, 2004):

- Use of experimental contamination of hands or normal hand microflora;
- Application of test organism (drying on or rubbing in);
- Type of hand hygiene agent;
- Concentration of active ingredient and volume of hygiene agent used; and
- Application method of hygiene agent and duration of contact.

3.1 Standardised Assessment Protocols

Standardised protocols have been developed in the USA and Europe for assessing the efficacy of hand hygiene products. These protocols use handwashing with soap and water as a reference method.

The European Protocol (EN1499 Chemical disinfectants and antiseptics – hygienic handwash – test methods and requirements (phase 2/step 2)) (Rotter, 2004) involves inoculating the hands with *E.coli* K12 and allowing them to dry. The hand hygiene product is then applied to the hands with a rubbing action for 30 or 60 seconds. The residual bacteria present on the hands before and after washing are determined using a hand rinse method. Efficacy is expressed as the log cfu reduction per hand (average of right and left hand). Handwashing with soap for 60 seconds is the reference standard. In an inter-laboratory study this method produced results of; pre-washing (mean ± SD) 6.32 ± 0.41 log (range 6.02-6.52) and post-washing 3.50 ± 0.51 (range 2.73-3.85), giving a reduction factor of 2.81 ± 0.49 (range 2.47-3.35) (Kampf and Ostermeyer, 2002).

The equivalent US protocol (ASTM E1174 American Society for Testing Materials – Standard test method for evaluation of healthcare personnel hand-wash) is qualitatively similar (Boyce and Pittet, 2002; Sickbert-Bennett *et al.*, 2004). A standardised solution of *Serratia marcescens* (5 ml) is applied to hands and rubbed over the surface of the hands. A specified amount of a hand hygiene agent is then applied with a minimal amount of water and lathered for a specified time. Hands are rinsed under 40ºC tap water for 30 seconds. Organisms are recovered from the hand by the 'glove juice' method (fastening an oversized glove containing sampling solution over the hand and massaging for 1 minute). Results are reported as log cfu reductions per hand.

3.2 Efficacy of Different Durations of Handwashing

A number of studies have been carried out using the standardised protocols outlined above or procedures that are qualitatively similar. Two main groups of studies have been carried out; those that look at the ability of handwashing to remove a particular micro-organism artificially applied to the hands, and those that look at the ability of handwashing to remove natural transient microflora.

3.2.1 Studies with artificially contaminated hands

The results of relevant studies reported in terms of log reductions in microbial numbers are summarised in Table 2. Reductions are usually expressed in terms of the total organisms per hand or defined portion of the hand (e.g. the fingertips). Where information on the variability in the log reduction is provided in the original study, this information has been included. Please note variability is expressed in a range of forms (range, standard deviation, 95th percentile confidence interval) and relevant footnotes should be referred to.

Table 2: Impact of different handwashing durations on removal of transient microflora from artificially contaminated hands

Organism	Duration of handwashing	Mean log reduction (range)	Reference
Escherichia coli	10 seconds	0.5 (0.1-1.6)[1,5] 1.3 (1.1-1.6)[2,5]	(Ansari *et al.*, 1989)
		1.09 (± 0.51)[3,5] 1.18 (± 0.24)[4,5]	(Lin *et al.*, 2003)
		1.66-1.91	(Fischler *et al.*, 2007)
		2.67	(Fuls *et al.*, 2008)
	30 seconds	2.41 (± 0.85)	(Ayliffe *et al.*, 1978)
		3-4	(Lowbury *et al.*, 1964)
	60 seconds	2.7 (1.69-3.63)	(Rotter and Koller, 1991)
		1.6-3.0	(Rotter and Koller, 1992)
		2.81 (2.47-3.35)	(Kampf and Ostermeyer, 2002)
		3.23	(Mittermayer and Rotter, 1975)
	120 seconds	3.27	(Mittermayer and Rotter, 1975)
Serratia marcescens	10 seconds	1.39 (1.18-1.61)[6] 1.87 (1.64-2.10)[7]	(Sickbert-Bennett *et al.*, 2005)
	15 seconds	1.08 (0.75-1.41)	(Fuls *et al.*, 2008)
	20 seconds	2.29 (± 0.52)	(Paulson *et al.*, 1999)
	30 seconds	2.27 (1.03-3.47)	(Nicoletti *et al.*, 1990)
Shigella flexneri	15 seconds	1.72 (1.56-1.88)	(Fuls *et al.*, 2008)
	30 seconds	1.67 (1.43-1.89)	(Fuls *et al.*, 2008)
		1.42-1.55	(Fischler *et al.*, 2007)
Pseudomonas aeruginosa	15 seconds	1.1 (1.0-1.3)	(Ojajarvi, 1980)
	30 seconds	2.23 (0.77-3.88)	(Ayliffe *et al.*, 1978)
		2-3	(Lowbury *et al.*, 1964)
	120 seconds	1.7 (1.6-1.8)	(Ojajarvi, 1980)
Staphylococcus aureus	15 seconds	0.6 (0.5-0.8)	(Ojajarvi, 1980)
	30 seconds	2.31 (± 0.58)	(Ayliffe *et al.*, 1978)
		2-3	(Lowbury *et al.*, 1964)
		0.53-1.76	(Lilly and Lowbury, 1978)
	120 seconds	0.8 (0.7-1.0)	(Ojajarvi, 1980)
MRSA	30 seconds	1.77 (± 1.80)[8,5] 1.96 (± 1.65)[9,5]	(Guilhermetti *et al.*, 2001)
Staphylococcus saprophyticus	30 seconds	2.49 (± 0.43)	(Ayliffe *et al.*, 1978)

Organism	Duration of handwashing	Mean log reduction (range)	Reference
Clostridium difficile	10 seconds	2.0-2.4	(Bettin *et al.*, 1994)
Acinetobacter baumannii	30 seconds	1.1[8] 3.5[9]	(Cardoso *et al.*, 1999)
Bacillus atrophaeus	10 seconds	2.4 (2.2-2.5)[10]	(Weber *et al.*, 2003)
	30 seconds	2.3 (2.2-2.4)[10]	(Weber *et al.*, 2003)
	60 seconds	2.1 (1.9-2.4)[10]	(Weber *et al.*, 2003)
Micrococcus luteus	30 seconds	1.5 (1.10-2.20)	(Nicoletti *et al.*, 1990)
Bacteriophage MS2	10 seconds	1.85 (1.41-2.28)[10]	(Sickbert-Bennett *et al.*, 2005)
Feline calicivirus	15 seconds	1.89 (± 0.31)[3,5] 1.82 (± 0.46)[4,5]	(Lin *et al.*, 2003)
Poliovirus 1	30 seconds	1.9	(Schurmann and Eggers, 1985)
Rotavirus	10 seconds	0.9 (0.8-1.0)[1,5] 1.2 (1.0-1.6)[2,5]	(Ansari *et al.*, 1989)
	30 seconds	1.18 (-0.2-2.7)	(Bellamy *et al.*, 1993)

[1] Finger pad method
[2] Whole hand method
[3] Artificial fingernails
[4] Natural fingernails
[5] Range figures are the standard deviation
[6] Without proteinaceous material
[7] With proteinaceous material
[8] Figures relate to heavy hand contamination
[9] Figures relate to light hand contamination
[10] Values given for the range are the 95th percentile confidence interval

A number of these studies reported using one or other of the standardised protocols outlined in section 3.1 (Fischler *et al.*, 2007; Fuls *et al.*, 2008; Kampf and Ostermeyer, 2002; Rotter and Koller, 1991; Sickbert-Bennett *et al.*, 2004; Sickbert-Bennett *et al.*, 2005; Weber *et al.*, 2003), while other procedures appear to be nearly identical (Mittermayer and Rotter, 1975; Paulson *et al.*, 1999; Rotter and Koller, 1992; Schurmann and Eggers, 1985). The remaining studies mainly differed in contaminating and assessing a specific portion of the hands (e.g. fingertips, palm, forefinger). *E. coli* is the main organism for which results are contributed from studies with differing methodologies. However, there is no evidence to suggest that the results from studies using standardised protocols are any more reliable than studies using other protocols.

Interpretation of these data is complicated by the variability between different studies using the same combination of organism and handwashing duration. There is also considerable variability within some individual studies. For example, the log reduction in *E. coli* after a 10 second wash has been reported to vary from 0.5 (Ansari *et al.*, 1989) to 2.67 logs (Fuls *et al.*, 2008). Also, there is only one study (Weber *et al.*, 2003) that examined more than two washing durations. For single studies that considered more than one handwashing duration the following observations can be made:

- No additional removal of *E. coli* after 2 minutes washing compared to a 1 minute wash (Mittermayer and Rotter, 1975).
- No additional removal of *Shigella flexneri* after 30 seconds washing compared to a 15 second wash (Fuls *et al.*, 2008).
- No or little additional removal of *Pseudomonas aeruginosa* or *Staphylococcus aureus* after 2 minutes compared to a 15 second wash (Ojajarvi, 1980).
- No additional removal of *Bacillus atrophaeus* after 30 or 60 seconds compared to a 10 second wash (Weber *et al.*, 2003).

These results suggest that the duration of handwashing has little impact on microbial removal and that handwashing durations as short as 10-15 seconds may be as effective as longer durations.

The most comprehensive data are available for the removal of *Escherichia coli* from hands by washing with soap. While there is considerable variation between different studies it appears that little further removal of bacteria is achieved for wash durations greater than 30 seconds.

Unfortunately only one published study, using contamination with *Serratia marcescens*, has been conducted using the 20 second wash duration recommended in New Zealand (Paulson *et al.*, 1999).

A 30 second wash gives an approximate 2 log reduction (range 1.1-4.0 log) for most organisms studied.

An unpublished New Zealand study determined removal of added *E. coli* by three protocols (hands static under running water, hands rubbed under running water, and hands rubbed with soap under running water) for durations of 5, 10, 15 and 20 seconds (Patrick and Miller, Unpublished). Efficiency of handwashing was assessed by the number of bacteria transferred to a food item following handwashing. Washing for 20 seconds with rubbing and soap resulted in the biggest decrease in bacterial transfer with an approximate 2.7 log reduction in cfu transferred to a representative food (liquorice). Log reductions at 5, 10 and 15 seconds washing were 2.1, 2.1 and 2.4 log cfu respectively. While the log reductions are not inconsistent with studies in Table 2, the experimental details were somewhat different in that hands were washed under running water (enabling continual removal of bacteria) and remaining bacteria were measured in terms of their ability to transfer, rather than in terms of numbers remaining on hands. No washing times longer than 20 seconds were considered.

3.2.2 Studies with natural transient hand flora

The results of relevant studies reported in terms of log reductions in microbial numbers are summarised in Table 3. Where information on the variability in the log reduction is provided in the original study, this information has been included. Please note variability is expressed in a range of forms (range, standard deviation, 95th percentile confidence interval) and relevant footnotes should be referred to.

Table 3: Impact of different handwashing durations on removal of transient microflora from naturally contaminated hands

Duration of handwashing	Mean log reduction	Reference
10 seconds	0.7	(Lucet *et al.*, 2002)
15 seconds	0.11	(Larson and Laughon, 1987)
	0.59 (aerobes) 0.5 (anaerobes)	(Larson *et al.*, 1986)
	0.71 (± 0.79)[1]	(Takeshita *et al.*, 2002)
20 seconds	0.23	(Miller *et al.*, 1994)
30 seconds	0.6 (0.2-0.9)[2,4] 0.7 (0.3-1.2)[3,4]	(Kac *et al.*, 2005)
	0.5	(Lucet *et al.*, 2002)

[1] Range figures are the standard deviation
[2] Palms
[3] Fingertips
[4] Range figure are the 95th percentile confidence interval

While considerably fewer data are available for removal of transient microflora from naturally-contaminated hands, reductions achieved through handwashing are generally lower than those achieved on artificially-contaminated hands (Table 2). This appears to be due, at least in part, to lower numbers of organisms on the hands. For example, the study of Takeshita *et al*. reported hand contamination concentrations of 2-4 logs per hand and the study of Kac *et al*. reported 50-150 cfu per palm, while studies in Table 2 typically employed microbial concentrations in excess of 4 logs per hand. It is also possible that the distinction between transient and resident organisms is less clear-cut in the studies shown in Table 3 than those in Table 2. Determining total organisms, rather than a specific tracer, does not allow any distinction to be made between transient and resident microorganisms.

3.3 Other Studies

In a study of *Salmonella* cross-contamination in a kitchen environment, Barker *et al.* demonstrated that, after handling chicken inoculated with *Salmonella*, a 2 minute wash with soap and water was necessary to reduce *Salmonella* to an undetectable level if chicken grease was present (Barker *et al.*, 2003). However, a 30 second handwash was sufficient to remove *Salmonella* applied to the hands in a suspension without organic soiling. After handling poultry, washing the hands in a bowl containing anionic detergent for 30 seconds reduced the level of *Salmonella* contamination from 70% of hands having greater than 1000 cfu and 90% having greater than 100 cfu to 100% having greater than 10 cfu, but none having greater than 100 cfu. Addition of a 20 second rinse step (cold water) further reduced contamination to only 60% carrying detectable *Salmonella* and 25% carrying greater than 10 cfu.

4 HAND-DRYING

Far fewer studies are available to assess parameters associated with the drying of hands following handwashing. Duration of hand drying was not a focus for most studies. Studies can be grouped into three general categories:

- Studies that found no appreciable difference between different hand drying methods;
- Studies that found hot air drying to be the least effective method for microbial removal; and
- Studies that found hot air drying to be the most effective method for microbial removal

No standardised protocols, such as those outlined for handwashing in section 3.1, were found for assessing the effectiveness of hand drying.

In an early study on this topic, no appreciable differences were noted in the total bacteria left on hands after a standard wash and drying by individual linen hand towels, continuous linen towels, paper towels (2) or paper towels and hot air dryer (Davis *et al.*, 1969). Drying times varied by drying method and were in the range 10 seconds (continuous linen towel) to 17 seconds (paper towel plus hot air drying).

Hot air drying, paper towel drying and cloth towel drying were examined following washing of hands artificially contaminated with *E. coli* (Boursillon and Riethmuller, 2005). No difference was noted between hot air and paper towel drying, with neither method providing significant further changes in bacterial counts over and above handwashing (log reductions for drying were both 0.07). Cloth drying resulted in a small increase in bacterial counts on hands (log reduction -0.17).

Gustafson *et al.* examined the efficacy of the same three drying methods (hot air, paper towel, cloth towel), as well as spontaneous room air evaporation, following artificial contamination of hands with *Micrococcus luteus* and a 30 second wash with non-medicated soap (Gustafson *et al.*, 2000). A 15 second duration was used for towel drying and a 30 second duration for hot air drying. Spontaneous evaporation proceeded until hands were visibly dry. This study found no significant difference between pre-wash and post-dry bacterial counts when different methods were compared pairwise.

Blackmore found use of paper towels and continuous cotton towels to result in similar reductions in bacterial numbers on hands (Blackmore, 1989). However, on average hot air drying resulted in an increase in the number of bacteria on hands compares to counts before washing. The model of hot air dryer appeared to have little impact on this result, although cycle times varied considerably from 30 to 50 seconds.

Hanna *et al.* compared drying by paper towel, linen towels or hot air drying for removal of a tracer inoculum of *Serratia marcescens* following a standardised water wash (Hanna *et al.*, 1996). Both towel techniques performed similarly and both performed better than hot air drying for removal of the tracer organism. The hot air dryer was shown to result in contamination of the immediate environment with the tracer organism. Hot air drying was for a period of 30-45 seconds. The time of towel drying was not stated.

Taylor *et al*. (2000) found no significant difference between hot air drying and hand drying with paper towels on the changes in microbiological status of hands, as assess by a finger rinse method (Taylor *et al.*, 2000). However, when a contact plate method was used paper towels were significantly better for reducing the microbiological contamination on washed hands. An assessment of hot air drying times (10 and 20 seconds and 30, 35, 40 or 45 seconds) was also carried out (Taylor *et al.*, 2000). The microbiological status of hands was improved at longer drying times (30-45 seconds) – when the hands were judged to be dry.

Yamamoto *et al.* compared the performance of hot air (60 ± 2ºC, 15 or 30 seconds, with or without hand rubbing) and paper towel (1-3 sheets) drying (Yamamoto *et al.*, 2005). When the hands were rubbed the bacterial counts increased at 15 seconds drying compared to before drying. After 30 seconds of drying with hand rubbing counts had decreased on the fingertips compared to before drying, but had not decreased on the palms and fingers. For hands held stationary bacterial counts decreased after 15 seconds and decreased further after 30 seconds drying. Drying with paper towels resulted in no significant change in bacterial counts on palms and fingers, but a significant decrease in bacterial counts on fingertips compared to before drying. Warm air drying with hands stationary was more effective for removing bacteria than paper towel drying. The authors speculated that the increases seen with hand rubbing were due to bacteria in the skin follicles migrating to the surface.

Ansari *et al.* found that hot air drying resulted in lower residual counts of an *E. coli* or rotavirus tracer, following a standardised handwash, than paper towel drying or cloth towel drying (Ansari *et al.*, 1991). The study only assessed microbial contamination of the finger pads and used a standard 10 second drying time for all drying procedures.

Patrick *et al.* measured residual water on hands after various durations of cloth towel drying or hot air drying (Patrick *et al.*, 1997). For cloth towel drying, 4% of residual water remained on the hands after 10 seconds drying. This figure further reduced to 1% of residual water after 15 seconds drying. Hot air drying for 45 seconds was required to reduce the residual water remaining on hands to 3% of initial values. Patrick *et al*. used the ability of wet hands to transfer microorganisms to other surfaces (skin, food, utilities) as an indicator of drying efficacy. For cloth towel drying, after 15 seconds of drying the hands transferred 3-11% of the bacteria that they transferred when fully wet (drying time = 0 seconds). After 45 seconds of drying these figures had further reduced to 1-2%. After 20 seconds of hot air drying hands still transferred 23-26% of the microorganisms transferred by fully wet hands, while after 45 seconds of drying this figure had reduced to 2-6%. In an associated observational study in a rest room environment patrons were observed to air dry their hands for a mean duration of 17.0/13.3 seconds (males/females) and 3.5/5.2 seconds (males/females) for cloth towel drying (Patrick *et al.*, 1997).

5 CONCLUSIONS

Despite a significant body of information on factors associated with handwashing and hand drying, guidelines for health care professionals and the general public appear to be generally based on expert opinion (Larson, 1995; Pratt *et al.*, 2001; Pratt *et al.*, 2007).

For handwashing, there is some evidence to suggest that washing times in excess of one minute provide little or no extra benefit with respect to removal of transient micro-organisms (Mittermayer and Rotter, 1975; Ojajarvi, 1980). In some cases evidence suggests no additional benefit in handwashing durations greater than 10-15 seconds (Fuls *et al.*, 2008; Weber *et al.*, 2003).

Handwashing for a duration of 30 seconds has been shown to result in a decrease in microbial counts of the order of two log units for a range of organisms artificially applied to hands (see Table 2). However, there is little evidence to suggest an optimum duration of handwashing in the range 10-60 seconds.

There is even less evidence to support guidelines for the duration of hand drying. While some studies suggest superior microbial removal with one method or other, in general no consistent significant differences have been observed. Achieving fully dry hands appears to be important and studies suggest that this will be achieved in a shorter time frame by the use of towels (paper or cloth) than hot air dryers.

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