



RESEARCH ARTICLE

Hand Washing Before and After Applying Different Hand Hygiene Techniques in Places of Public Concern in Tripoli-Libya

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Abstract:

Background:

Hand hygiene has been considered as one of the primary measures to improve standards and practice for hospital care and to minimize the transmission of nosocomial pathogens. There is substantial evidence that incidence of hospital acquired infections is reduced by applying hand antiseptics. Regarding hand hygiene and public concern, hand washing has revealed that 85% of the observed adults wash their hands after using public toilets.

Objective:

To compare the efficacy of hand rubbing with an alcohol based solution versus conventional hand washing with antiseptic and non-antiseptic soaps in reducing bacterial counts using different hand hygiene techniques.

Methods:

Ninety-three volunteers took part in this study; 57 from Tripoli Medical Center (TMC); 16 from school; 11 from bank; and 9 from office. All volunteers performed six hand hygiene techniques, immediately before and after a volunteer practice activity: hand washing with non-antiseptic soap for 10 and 30 second (s); hand washing with antiseptic soap for 10, 30 or 60 s; and alcohol-based hand rub. A total of 864 specimens were taken: 432 before and 432 after volunteer's hand hygiene. The fingertips of the dominant hand for each volunteer were pressed on to agar for culture before and after each hand hygiene technique. Plates were incubated at 37°C, and colony-forming units were counted after 48 hours and pathogenic bacteria were identified.

Results:

Results showed that 617 specimens (71.41%) were positive for bacterial growth. 301 (48.78%) were from TMC, 118 (19.12%) were from office; 107 (14.34%) were from school and 91 (14.75%) were from bank.

Conclusion:

Both antiseptic and non-antiseptic soaps did not work properly in reducing bacterial counts of worker's hands at all places of study, but significantly improved by an application of alcohol based gel.

Keywords: Hand hygiene, Hand washing, Hospital acquired infections, Microbial contamination, Alcohol based gel.

1. INTRODUCTION

Hand washing is the first line of defence and is one of the oldest methods of preventing the spread of disease. Public health officials pay attention to the Health Care Workers (HCWs) in hospitals and in places related to human activity by

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urging people to wash and/or hygiene their hands more frequently to fight occurring of infectious diseases. In terms of definition, hand washing is a process of hand cleaning using water and/or soap for the purpose of physically or mechanically removing dirt and organic material. By contrast hand hygiene is a general term referring to any action of hand cleansing for the purpose of reducing or inhibiting the growth of microorganisms through the application of an antiseptic hand rub or through antiseptic hand washing [1].

One of the most important steps in avoiding getting sick and preventing spread of microbes to others is by keeping hands clean. Neglecting washing hands with soap and clean running water will lead to spread many types of diseases. Centres for Disease Control and Prevention (CDC) [2], revealed that almost 50% of all foodborne illness outbreaks occur due to failing to wash or insufficiently washing hands. A review from 1975 to 1998 showed that unwashed hands of infected food workers are responsible for transmitting pathogens on food and resulting in 93% of the foodborne disease outbreaks [2, 3]. Additionally, diarrheal disease risks can be reduced by more than 40% when hands washed with soap and that hand washing interventions could save one million lives annually [4].

Thinking Wet, Lather, Scrub, Rinse, and Dry are the five simple and effective steps of hand washing like a “do-it-yourself” vaccine. Removing microbes, avoiding getting sick, and preventing the spread of microbes to others can be successfully achieved by applying regular hand washing, particularly before and after certain activities [5]. In this respect, the development in the guidance for effective hand washing and use of hand sanitizer was almost based on data from a number of studies [4, 6, 7].

Since a decade ago approximately in 2002 when CDC published its “Guideline for hand hygiene in Health-Care Settings, and the question that still excite is: Does all that hand washing and gelling work?

Hand hygiene has being considered as one of the primary measures to improve standards and practice for hospital care and to minimize the transmission of nosocomial pathogens.

Although cross infection *via* the hands of health care personnel is responsible for an estimated 20% to 40% of nosocomial infections, still the patient’s endogenous flora considered as a major source of nosocomial pathogens. Noncompliance with hand hygiene, however, remains a major problem in hospitals, and compliance with hand washing in hospital environments is generally less than 50% [8].

The intensity of environmental contamination is strongly correlated with the frequency of positive personnel hand culture [11]. For example, 0% to 25% environmental contamination represents 0% hand contamination, 8% when environmental contamination was 26% to 50%, and when environmental contamination was greater than 50% the hand contamination was 36%.

There is a substantial evidence that incidence of Hospital Acquired Infections (HAIs) is reduced by applying hand antisepsis [9 - 24]. Therefore, patient’s safety is fundamentally ensured by the action of hand hygiene as a process of care in a timely and effective manner. However, unacceptably low compliance with hand hygiene is to be taken as universal in health care [25]. This contributes to low number of transmission microbes capable of causing HAIs. However, reduction in HAIs can be successful achieved by better adherence to hand hygiene guidelines and policies [26 - 32].

Recently, new approaches have been introduced despite improvements in understanding of the epidemiology of hand hygiene compliance [33, 34]. A group of international professionals from the Centers for Disease Control and Prevention, the Healthcare Infection Control Practices Advisory Committee, the Society for Healthcare Epidemiology of America, the Association for Professionals in Infection Control and Epidemiology have developed guidelines for hand hygiene in healthcare settings [35] and anticipated that these guidelines should improve the standards and practice in healthcare settings. Unfortunately, it has been always documented in several literature studied that the importance of hand hygiene is not sufficiently recognized HCWs [36-38] and compliance with recommended practices is unacceptably low [33 - 46]. Moreover, as the average level of compliance with hand hygiene recommendations is low, also the time spent is usually insufficient. An observational studies showed that the duration time of hand washing or hygienic hand wash spent by HCWs varies from few seconds to more than a minute, and the average is between 4.7 and 24 seconds [35]. Despite this short period of washing time, HCWs often fail to cover all surfaces of their hands and fingers [47] and to use an effective technique of hand hygiene, even under observation [48].

Investigations related to outbreaks have suggested an existing correlation between infections and understaffing or overcrowding which consistently linked with reduced compliance with hand hygiene practices [49 - 51]. Other investigation showed that transmission of Methicillin-Resistant *Staphylococcus aureus* (MRSA) considered as a risk

factor in an Intensive Care Unit (ICU) [52].

Larson and colleagues [53] documented that the prevalence of nosocomial infections decreased as HCWs' compliance with recommended hand hygiene measures improved. Top hospital management and medical and nursing leaders provided active support for a culture change, highlighting and enforcing the expectation for hand hygiene compliance for all HCWs.

Regarding hand hygiene and toilets as an example of a place of public concern related to human activity, an investigation study revealed that 85% of the observed adults wash their hands after using public toilets [54]. This habit of washing hands increased from 77% to 83% in years 2005 to 2007 respectively [55].

A study focusing on gender as a contribution factor in hand washing practices showed that, women usually wash their hands more frequently than men. The percentage of hand washing for women is 83%, whereas only 74% was recorded for men, as it had been observed in a study carried out by American Society for Microbiology in 2003 [56]. Women showed to be consistently wash their hands more than men during a multiyear study across public attractions. 90%, 88%, and 93% were the average observed hand washing percentages for women in the years 2005, 2007, and 2010 respectively. The equivalent percentages for men were 75% in 2005, 66% in 2007, and 77% in 2010 [54].

Regardless of simplicity of hand washing, it is seriously important in schools, where lots of things such as desks, books, pencils, food and even germs are shared. However without adapting a proper hand cleaning regime, students and their families and friends will get quickly infected by germs. A study involved 120 secondary school students [56] revealed that 58% of female students washed their hands after using toilets and only 28% of them used soap. In contrast 48% of male students do so with only 8% of them used soap [57].

In a university campus public toilets a study focusing on the effect of introducing hand washing sign to encourage hand washing found that 61% of women washed their hand regardless to the presence of sign, this washing rate climbed to 97% in the presence of sign, while the hand washing rate for men was 37% without sign and this rate fall to 35% when a sign is displayed [58]. In other study carried out in British highland washing service station toilets, showed that 65% of women and 32% of men washed their hands, but after displaying electronic screen sign the hand washing rate increased to as much as 71% for women and 35% for men [59].

2. METHODS

2.1. Setting and Study Design

This study was a prospective microbiological evaluation. The study was performed on volunteers from four different places of public concern in city of Tripoli, Libya namely; TMC Teaching Hospital, Zawiat El-Dehmani School, El-Wahda Bank, and Sook El-Juomah Education Bureau. Three units in TMC were studied: the surgical unit, the medicine unit, and the dermatology unit. All volunteers were screened for hand contamination within 24 hours twice per week. Colonized volunteers were placed under contact precautions. Each volunteer performed six hand hygiene techniques in random order: hand hygiene with non-antiseptic soap for 10 and 30 second (s); hand washing with antiseptic soap for 10, 30 or 60 s; and hand rubbing with alcohol-based hand antiseptic. The six hand hygiene techniques were typically performed over four week by each volunteer.

The non-antiseptic soap, the antiseptic soap and the alcohol-based antiseptic used in this study are listed in Table 1. Before each monitoring period, a selective agar media were used (Nutrient agar NA; MacConkey agar MCA; Blood agar BA & Mannitol salt agar MSA), each volunteer in this study was invited to informed consent. The information included; age, sex, job category, health condition of the hands and use of antibiotics in the past month were collected from each volunteer.

Table 1. Types of disinfectants used in this study.

| Antiseptic Trade Name | Description | Manufacturer | Place of Use |
|-----------------------|---------------------|------------------------------|---|
| Medix Red grape | Non-antiseptic soap | Mexon, Bulgaria | TMC (Medical & Surgical units), School Education Bureau |
| Lux | Non-antiseptic soap | Unilever, UK | TMC Dermatology unit & Bank |
| Lifebuoy | Antiseptic soap | Unilever Global, India | TMC (medical & surgical units) |
| Dettol | Alcohol gel | Reckitt Benckiser, Indonesia | TMC Medical unit & Education Bureau |

(Table 1) contd....

| Antiseptic Trade Name | Description | Manufacturer | Place of Use |
|-----------------------|-----------------|--|---|
| Lifebuoy | Antiseptic soap | Unilever Global, India | TMC (medical & surgical units), School & Education Bureau |
| Dettol | Antiseptic soap | Reckitt Benckiser, Arabia, USA | TMC Dermatology unit & Bank |
| Lovillea | Alcohol gel | Unilever Global, India | TMC Medical unit & Education Bureau |
| Dettol | Alcohol gel | Reckitt Benckiser, Indonesia | TMC Surgical unit & School |
| Genera | Alcohol gel | Farness s.r.i. Laboratory Cosmetic, Due Garrare, Italy | Bank |
| Dettol | Alcohol gel | Rackitt and Colam, UK | TMC Dermatology unit |

2.2. Microbiological Techniques

After a procedure, three fingertips on the dominant hand of the volunteer were pressed on the surface of agar plate for approximately 15 second. In order to obtain identical conditions for each specimen, the agar was applied on to the fingers by the help of the students to obtain identical pressure. The hand hygiene technique was then performed, and a second imprint of the fingertips was obtained one minute later. Plates were incubated at 37°C under aerobic conditions, and Colony-Forming Units (CFUs) were counted after 48 hours. The maximum count was 300 CFUS; beyond this figure, it was considered too many to count (TMTC). Potential pathogenic bacteria from transient were identified using standard microbiological techniques (Gram staining biochemical tests) and Phoenix reading using Phoenix machine (BD Phoenix™ ID/ASTBD Diagnostic, Dickinson and Company, Sparks, MD 21152-0999) at Diseases Control Centre in Tripoli-Libya.

3. RESULTS

A total of 93 volunteers took part in the study Table 2; 18 from TMC surgery unit (5 physicians, 7 nurses, 3 patients, and 3 health workers HCWs); 19 from TMC medicine unit (8 physicians, 5 HCWs, 4 patients, and 2 nurses); 20 from TMC dermatology unit (4 physicians, 13 nurses, and 3 patients) 16 from school (7 teachers, 5 students, 2 officers, 1 security man, and 1 kitchen worker); 11 from bank (6 accountants, 3 security men, 1 cleaner, and 1 kitchen worker); and 9 from office (7 employees, 1 cleaner, and 1 kitchen worker). There were 53 women and 21 men, with average age of 13-50 years. All volunteers performed six hand hygiene techniques.

Table 2. Number and characterization of volunteers involved in the study.

| Place | Volunteer's Characterization | | | | | | | | |
|----------------------|------------------------------|---------|----------------|----------------|-----------------|-------------|--------|----|-------|
| | Physician | Nurse | Patient | HCWs | Kitchen Workers | Average Age | Gender | | |
| | | | | | | | M | F | Total |
| TMC Surgery unit | 5 | 7 | 3 | 3 | - | 23 - 47 | 4 | 14 | 18 |
| TMC Medicine unit | 8 | 2 | 4 | 5 | - | 28 - 48 | 2 | 17 | 19 |
| TMC Dermatology unit | 4 | 13 | 3 | - | - | 25 - 40 | 4 | 16 | 20 |
| School | Student | Teacher | Officer | Security | Kitchen workers | Average age | Gender | | |
| | 5 | 7 | 2 | 1 | 1 | 13 - 50 | 5 | 11 | 16 |
| Bank | Accountant | Cleaner | Security | Kitchen worker | Average age | Gender | | | |
| | 6 | 1 | 3 | 1 | 30 - 45 | 5 | 6 | 11 | |
| Office | Employee | Cleaner | Kitchen worker | | Average age | Gender | | | |
| | 7 | 1 | 1 | | 30 - 47 | 3 | 6 | 9 | |
| TOTAL VOLANTEERS | | | | | | | 23 | 70 | 93 |

In an investigation carried out by gram staining technique on different places of the study, the number and distribution of identified bacteria (as gram positive or gram negative) revealed that a total of 874 specimens were collected: 437 before and 437 after hand hygiene. 627 (71.74%) were cultured-positive (*i.e.* growth) and 247 (28.26%) were cultured-negative (no growth). 507 (80.86%) of positive-culture specimens were gram positive bacteria, and 120 (19.14%) were gram negative bacteria. 305 (48.64%) out of gram positive-culture specimens were from TMC [106 (34.75%) from medicine unit (83.02% gram positive 16.98% gram negative bacteria); 101 (33.11%) from surgery unit (75.25% gram positive & 24.75% gram negative bacteria); 94 (30.82%) from dermatology unit (85.11% gram positive

& 14.89% gram negative bacteria); 2 (0.66%) from washing water (100% gram negative bacteria), 118 (18.82%) were from office (81.36% gram positive & 18.64% gram negative bacteria); 107 (17.07%) were from school (79.44% gram positive & 20.56% gram negative bacteria); 91 (14.51%) were from bank (83.52% gram positive & 16.48% gram negative bacteria) and 6 (0.96%) were from environmental air (100% gram positive bacteria).

A total of 44 potential pathogenic bacterial strains were isolated and identified. These bacterial strains are listed in Table 3. 21 bacterial strains were isolated from TMC; 6 from surgical unit; 4 were Methicillin Resistant Strains MSR; (2 *Staphylococcus aureus* and 2 *Staphylococcus capitis*), the other two namely *Escherichia coli* and *Enterococcus* spp. were isolated from water used for washing, while 7 bacteria were isolated from medicine unit, 3 of them were MRS (*Staphylococcus aureus*, *Staphylococcus haemolyticus*, *Staphylococcus capitis*), the others were *Pasteurella aerogene*, *Serratia marcescens*, *Morganella morganii* and *Streptococcus porcini*. In dermatology unit 6 bacterial strains were isolated namely; *Aeromonas veroni*, *Aeromonas veroni*, *Micrococcus lylae* & *Aeromonas sorbia*. On the other hand, 8 bacterial strains were isolated from school (2 *Proteus vulgaris*, 2 *Staphylococcus aureus*, *Morganella morganii*, *Pseudomonas species*, *Staphylococcus epidermidis*, & *Aeromonas veronii*). In addition 5 bacterial strains were isolated from bank (*Staphylococcus aureus*, *Staphylococcus capitis* *Proteus panninger*, *Proteus vulgaris* & *Aeromonas veronii*) and lastly 7 strains were isolated from the environmental air of all places [54 - 69]

Table 3. Number and distribution of samples tested from different places of the study.

| Total Samples Tested (874) | | Places of Study | Growth | | | | | |
|----------------------------|--------------|----------------------|--------|-------|---------------|-------|---------------|-------|
| Growth | No Growth | | Total | | Gram Positive | | Gram Negative | |
| | | No. | % | No. | % | No. | % | |
| - | - | Hospital (TMC) | 305 | 48.64 | - | - | - | - |
| - | - | TMC Surgical unit | 101 | 33.11 | 76 | 75.25 | 25 | 24.75 |
| - | - | TMC Medicine unit | 106 | 34.75 | 88 | 83.02 | 18 | 16.98 |
| - | - | TMC Dermatology unit | 94 | 30.82 | 80 | 85.11 | 14 | 14.89 |
| 627 (71.74%) | 247 (28.26%) | TMC Washing water | 6 | 0.66 | - | - | 2 | 100 |
| - | - | School | 107 | 17.07 | 85 | 79.44 | 22 | 20.56 |
| - | - | Bank | 91 | 14.51 | 76 | 83.52 | 15 | 6.48 |
| - | - | Office | 118 | 18.82 | 96 | 81.36 | 22 | 18.64 |
| - | - | Environmental air | 6 | 0.96 | 6 | 100 | - | - |

TMC, Tripoli Medical Centre; No., Number.

4. DISCUSSION

The study was carried out in four different places of public concern (hospital, school, bank and office) in Tripoli city-Libya, during the routine practices of volunteers. High rate of contamination was demonstrated with potential nosocomial pathogens. Approximately, 70% of specimens taken from volunteer's hands (especially HCWs) were found contaminated with at least one pathogen during their routine work. These findings agree with previous studies concerning hand hygiene which indicated that, the frequent contamination of HCWs hands [70 - 74].

The results have shown that hand rubbing with an alcohol-gel is more effective than hand washing with either antiseptic soap or non-antiseptic soap in reducing bacterial contamination of volunteer's hands. This might be due in part to the inadequate time spent in hand washing conventionally, high bacterial contamination of washing water (especially in TMC), and microbial contamination of the environmental air.

Several studies in which hands were artificially contaminated with different microorganisms have shown that hand rubbing with alcohol based products is more effective than hand washing with non-antiseptic soap or antiseptic soap [75 - 89]. Most of these studies incorporated supervised hand hygiene techniques to ensure conformity to usual recommendations or at least insisted on the quality of techniques. In this study, these specifications were in some instant difficult to be controlled by the students. Despite these specifications, standard techniques of hand washing were always found to be less efficient than hand rubbing in removing transit contamination on hands. Although this study was

designed not to interfere with the actual practice of volunteers in terms of compliance with and quality of hand hygiene, the main objective being to evaluate the efficacy in routine work before and after performing various hand hygiene techniques Table 4.

Table 4. Phoenix identification of bacterial strains isolated from volunteer’s hands.

| Places of Study | Isolated Bacterial Strains | Number of Isolates (Samples Tested) |
|----------------------------------|---|-------------------------------------|
| TMC Surgical unit | 2 <i>Staph. capitis</i> (MRS), 2 <i>Staph. aureus</i> (MRS), <i>E. coli</i> & <i>Enterococcus spp.</i> | 6 (101) |
| TMC Medicine unit | <i>Staph. haemolyticus</i> (MRS), <i>Staph. capitis</i> (MRS), <i>Staph. aureus</i> (MRS), <i>Pasteurella aerogene</i> , <i>Serratia marcescens</i> , <i>Morganella morganii</i> & <i>Strep. porcinis</i> | 7 (106) |
| TMC Dermatology unit | 2 <i>Aeromonas veroni</i> , 2 <i>Proteus vulgaris</i> , <i>Micrococcus lylae</i> & <i>Aeromonas sorbia</i> | 6 (94) |
| TMC Washing water | <i>E. coli</i> & <i>Klebsiella spp.</i> | 2 (4) |
| School | 2 <i>vulgaris</i> , 2 <i>Staph. aureus</i> , <i>Staph. epidermidis</i> , <i>Pseudomonas Proteus species</i> , <i>Morganella morganii</i> & <i>Aeromonas veronii</i> . | 8 (107) |
| Bank | <i>Staph. aureus</i> , <i>Staph. capitis</i> (MRS), <i>Proteus pannier</i> , <i>Proteus vulgaris</i> & <i>Aeromonas veroni</i> | 5 (91) |
| Office | <i>Staph. Aureus</i> (MRS), <i>Actinobacillus lignieresii</i> , <i>Staph. lentus</i> (MRS) & <i>Enterobacter cloacae</i> | 4 (118) |
| Air | 2 Methicillin <i>Staph. aureus</i> (MRS), 2 <i>Bacillus spp.</i> , <i>Serratia spp.</i> , <i>Micrococcus spp.</i> | 6 (6) |
| Total isolated bacterial strains | | 44 (627) |

The results of this study show that hand washing with antiseptic soap was at least as ineffective as washing with non-antiseptic soap. As indicated in Table 5, the reduction of CFUs of volunteer’s hands actually significantly higher after hand rubbing with alcohol gel than after soap washing. In contrast, hand washing with antiseptic soap for 60 second showed an acceptable reduction in CFUs of volunteer’s hands but was not as good as hand rubbing with alcohol based gel. In a study carried out by, Larson *et al.* found that hand rubbing was equivalent to hand washing with antiseptic soap in reducing hand contamination [11]. However, the contents of a product regarding percentage of alcohol and the type of antibacterial agents are very important factors for its efficacy in reducing hand contamination. A study by Girou *et al.*, showed that hand rubbing products contained 75% alcohol more effective than once contained 61%., also the study added the interference of the method of hand sampling and the types of hand hygiene techniques with the efficacy of hand hygiene techniques [68].

Table 5. Bacterial contamination of the hands before and after different hand hygiene techniques.

| Places of Study | Hand Washing Process | Hand Hygiene Techniques (Finger Imprint) Using | | | | | | | | | | | |
|----------------------|----------------------|--|------|------------------------------------|------|--------------------------------|------|--------------------------------|------|--------------------------------|------|------------------------|------|
| | | Non-Antiseptic Soap for 10 Seconds | | Non-Antiseptic Soap for 30 Seconds | | Antiseptic Soap for 10 Seconds | | Antiseptic Soap for 30 Seconds | | Antiseptic Soap for 60 Seconds | | Alcohol Based Hand Rub | |
| | | CFUs | % | CFUs | % | CFUs | % | CFUs | % | CFUs | % | CFUs | % |
| TMC Surgical unit | B | 128 | 19.9 | 169 | 17.8 | 133 | 27.8 | 27 | 51.9 | 121 | 74.4 | 100 | 95.0 |
| | A | 129 | | 139 | | 96 | | 14 | | 21 | | 5 | |
| TMC Medicine Unit | B | 120 | 21.7 | 216 | 13.9 | 119 | 29.4 | 87 | 83.9 | 150 | 94.0 | 130 | 98.5 |
| | A | 94 | | 186 | | 84 | | 14 | | 15 | | 2 | |
| TMC Dermatology Unit | B | 139 | 22.3 | 128 | 25.0 | 135 | 24.4 | 99 | 79.8 | 109 | 74.8 | 116 | 94.8 |
| | A | 108 | | 121 | | 102 | | 20 | | 25 | | 9 | |
| Average (%) | | | 14.3 | | 18.9 | | 27.2 | | 58.1 | | 81.1 | | 93.1 |
| School | B | 122 | 10.7 | 133 | 12.0 | 79 | 15.2 | 150 | 56.0 | 58 | 77.6 | 123 | 90.2 |
| | A | 109 | | 117 | | 67 | | 84 | | 13 | | 12 | |
| Bank | B | 79 | 11.4 | 56 | 10.7 | 80 | 13.8 | 146 | 59.6 | 70 | 77.1 | 96 | 90.6 |
| | A | 70 | | 50 | | 69 | | 59 | | 54 | | 9 | |
| Office | B | 127 | 4.7 | 68 | 11.8 | 61 | 14.8 | 150 | 26.7 | 80 | 61.3 | 40 | 77.5 |
| | A | 121 | | 60 | | 52 | | 110 | | 31 | | 9 | |
| Average (%) | | | 8.9 | | 11.5 | | 14.6 | | 47.4 | | 72.0 | | 86.1 |

B, Before hand hygiene; A, After hand hygiene; CFUs, colony forming units (average of finger imprint).

Regarding duration of washing and effect, previous studies proved that the recommended optimal duration of hand washing is 30 to 60 second. In this study, alcohol hand rubbing and hand washing were actually performed by volunteers for a similar length of time. The 30 second seems sufficient for hand rubbing with alcohol based gel but may not be long enough for hand washing with antiseptic soap and non-antiseptic soap. Most observational studies have shown that hand washing is very rare to be performed for more than 30 second [90 - 92], and this study comes in agreement with this finding confirming that 30 second hand washing was ineffective in reducing bacterial contamination of hands. Therefore, the rapid efficacy of alcohol based solutions compared with hand washing, even with an antiseptic agent, is a major argument supporting their use in clinical practice [93].

5. RECOMMENDATIONS

The use of waterless antiseptic agent is recommended for routine hand hygiene in all clinical situations especially when hands are not visibly soiled. Importantly, antiseptic hand rub has no effect on soil, so visibly soiled hands should be washed with soap and water.

A system change supported by good management would probably be necessary in most hospitals to change a hand hygiene agent, promote and facilitate skin care for HCWs' hands.

Education especially for HCWs' hands is of great importance to improve hand hygiene practices and must be promoted at all levels of experience. The potential risks of transmission of microorganisms to patients can be addressed by implementation of proper educational programs towards hand hygiene, as well as potential risks of HCWs colonization or infection acquired from the patient.

Hand washing is simple and particularly important in places related to human activity but very serious, where lots of things are shared for examples; desks, books, pencils, food and even germs. Without proper hand cleaning, a single infection can quickly spread among people.

CONCLUSION

Hand contamination was highest in hospital (TMC), followed by school, then bank and lastly office. The highest hand contamination observed in the hospital can be attributed to the large number of pathogens that usually harbor the hospital's environment. Both antiseptic and non-antiseptic soaps did not work properly in reducing bacterial counts of worker's hands at these places, but significantly improved by an application of alcohol based gel. This comes in agreement with previous studies which revealed that; alcohols hygienic hand rub, so-called 'waterless disinfection' is significantly more efficient than standard hand washing with non-antiseptic soap and water or water alone [34, 35]. Bacterial reduction after hand washing with antiseptic soap (either 10, 30 or 60 seconds) or hand rubbing with alcohol-based gel was significantly greater than that obtained after hand washing with non-antiseptic soap (either 10 or 30 seconds). Therefore results of swabbing technique showed that bacterial contamination occurred on hands before and after hand hygiene procedures in which high chance of contamination (personnel, cotton swab and air) might be occurred.

Reduction in bacterial counts was observed after longer hand washing with antiseptic soap (30 and 60 seconds), but the trends were different after hand washing with non-antiseptic soap (10 and 30 seconds), and antiseptic soap for 10 seconds in which no reduction in bacterial counts was observed and this can be attributed to the water used for hand washing procedures, especially in TMC was found to be highly contaminated. In addition, air contamination was observed in all places of study was another factor affected the hand washing with antiseptic soap and non-antiseptic soap.

The predominant isolated bacteria were from transient flora: *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Staphylococcus capitis*, *Staphylococcus haemolyticus*, *Proteus vulgaris*, *Morganella morganii*, and *Aeromonas veronii*. The specimens obtained after hand hygiene were still culture-positive in many cases of the study places when hand washing applied with non-antiseptic soap for 10, 30 second and antiseptic soap for 10 second. Microbial contamination, especially with MRS bacteria appeared in TMC specimens taken from volunteer's hands, an environmental air, and washing water suggested a high risk for spreading pathogens and increasing the spread of HAIs, if not properly controlled.

Antibiotic Sensitivity Test (AST) was carried out for some isolated bacterial strains. All strains exhibited resistance against the most of antibiotics.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this research.

CONSENT OF PUBLICATION

Informed consent were obtained.

CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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REFERENCES

- [1] Guzewich J, Ross MP. Evaluation of risk related to microbiological contamination of ready-to-eat foods by food preparation workers and the effectiveness of interventions to minimize those risks. Silver Spring, MD: Food and Drug Administration Centre for Food Safety and Applied Nutrition 1999.
- [2] Mead PS, Slutsker L, Dietz V, *et al.* Food-related illness and death in the United States. *Emerg Infect Dis* 1999; 5(5): 607-25. [<http://dx.doi.org/10.3201/eid0505.990502>] [PMID: 10511517]
- [3] Borchgrevink CP, JaeMin Cha, SeungHyun K. Hand washing practice in a college town environment. *J Environ Health* 2013; 75(6): 18-24. [PMID: 23621052]
- [4] Curtis V, Schmidt W, Luby S, Florez R, Touré O, Biran A. Hygiene: New hopes, new horizons. *Lancet Infect Dis* 2011; 11(4): 312-21. [[http://dx.doi.org/10.1016/S1473-3099\(10\)70224-3](http://dx.doi.org/10.1016/S1473-3099(10)70224-3)] [PMID: 21453872]
- [5] Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. *Am J Public Health* 2008; 98(8): 1372-81. [<http://dx.doi.org/10.2105/AJPH.2007.124610>] [PMID: 18556606]
- [6] Ejemot RI, Ehiri JE, Meremikwu MM, Critchley JA. Hand washing for preventing diarrhoea. *Cochrane Database Syst Rev* 2008; 1(1): CD004265. [PMID: 18254044]
- [7] Palit A, Batabyal P, Kanungo S, Sur D. In-house contamination of potable water in urban slum of Kolkata, India: A possible transmission route of diarrhea. *Water Sci Technol* 2012; 66(2): 299-303. [<http://dx.doi.org/10.2166/wst.2012.177>] [PMID: 22699333]
- [8] Lam BC, Lee J, Lau YL. Hand hygiene practices in a neonatal intensive care unit: A multimodal intervention and impact on nosocomial infection. *Pediatrics* 2004; 114(5): e565-71. [<http://dx.doi.org/10.1542/peds.2004-1107>] [PMID: 15492360]
- [9] Health Canada: Infection Control Guidelines: Hand washing, Cleaning, Disinfection and Sterilization in Health Care. Ottawa, Canada; Health Canada, Laboratory Centre for Disease Control Bureau of Infectious Diseases, Nosocomial and Occupational Infections. Dec. 1998.
- [10] Boyce JM, Pittet D. Guideline for hand hygiene in health care settings: Recommendations of the healthcare infection control practices advisory committee and the HICPAC/SHEA/APIC/IDSA hand hygiene task force. *Infect Control Hosp Epidemiol* 2002; 51((Suppl.): S3 – S40): 1-44. 23 Dec
- [11] World Health Organization (WHO). WHO Guidelines on Hand Hygiene in Health Care (Advanced Draft): A Summary. Geneva, Switzerland: WHO 2006.
- [12] Pratt RJ, *et al.* National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England. London: Research Wells Research Centre, Thames Valley University 2006.
- [13] Pittet D. Improving compliance with hand hygiene in hospitals. *Infect Control Hosp Epidemiol* 2000; 21(6): 381-6. [<http://dx.doi.org/10.1086/501777>] [PMID: 10879568]
- [14] Casewell M, Phillips I. Hands as route of transmission for Klebsiella species. *BMJ* 1977; 2(6098): 1315-7. [<http://dx.doi.org/10.1136/bmj.2.6098.1315>] [PMID: 589166]

- [15] Doebbeling BN, Stanley GL, Sheetz CT, *et al.* Comparative efficacy of alternative hand-washing agents in reducing nosocomial infections in intensive care units. *N Engl J Med* 1992; 327(2): 88-93.
[<http://dx.doi.org/10.1056/NEJM199207093270205>] [PMID: 1285746]
- [16] Webster J, Faoagali JL, Cartwright D. Elimination of methicillin-resistant *Staphylococcus aureus* from a neonatal intensive care unit after hand washing with triclosan. *J Paediatr Child Health* 1994; 30(1): 59-64.
[<http://dx.doi.org/10.1111/j.1440-1754.1994.tb00568.x>] [PMID: 8148192]
- [17] Zafar AB, Butler RC, Reese DJ, Gaydos LA, Mennonna PA. Use of 0.3% triclosan (Bacti-Stat) to eradicate an outbreak of methicillin-resistant *Staphylococcus aureus* in a neonatal nursery. *Am J Infect Control* 1995; 23(3): 200-8.
[[http://dx.doi.org/10.1016/0196-6553\(95\)90042-X](http://dx.doi.org/10.1016/0196-6553(95)90042-X)] [PMID: 7677266]
- [18] Pittet D, Hugonnet S, Harbarth S, *et al.* Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Infection control programme*. *Lancet* 2000; 356(9238): 1307-12.
[[http://dx.doi.org/10.1016/S0140-6736\(00\)02814-2](http://dx.doi.org/10.1016/S0140-6736(00)02814-2)] [PMID: 11073019]
- [19] Larson EL, Early E, Cloonan P, Sugrue S, Parides M. An organizational climate intervention associated with increased handwashing and decreased nosocomial infections. *Behav Med* 2000; 26(1): 14-22.
[<http://dx.doi.org/10.1080/08964280009595749>] [PMID: 10971880]
- [20] Conly JM, Hill S, Ross J, Lertzman J, Louie TJ. Handwashing practices in an intensive care unit: The effects of an educational program and its relationship to infection rates. *Am J Infect Control* 1989; 17(6): 330-9.
[[http://dx.doi.org/10.1016/0196-6553\(89\)90002-3](http://dx.doi.org/10.1016/0196-6553(89)90002-3)] [PMID: 2596730]
- [21] Simmons B, Bryant J, Neiman K, Spencer L, Arheart K. The role of handwashing in prevention of endemic intensive care unit infections. *Infect Control Hosp Epidemiol* 1990; 11(11): 589-94.
[<http://dx.doi.org/10.2307/30148433>] [PMID: 2258599]
- [22] MacDonald A, Dinah F, MacKenzie D, Wilson A. Performance feedback of hand hygiene, using alcohol gel as the skin decontaminant, reduces the number of inpatients newly affected by MRSA and antibiotic costs. *J Hosp Infect* 2004; 56(1): 56-63.
[[http://dx.doi.org/10.1016/S0195-6701\(03\)00293-7](http://dx.doi.org/10.1016/S0195-6701(03)00293-7)] [PMID: 14706272]
- [23] Swoboda SM, Earsing K, Strauss K, Lane S, Lipsett PA. Electronic monitoring and voice prompts improve hand hygiene and decrease nosocomial infections in an intermediate care unit. *Crit Care Med* 2004; 32(2): 358-63.
[<http://dx.doi.org/10.1097/01.CCM.0000108866.48795.0F>] [PMID: 14758148]
- [24] Hilburn J, Hammond BS, Fendler EJ, Groziak PA. Use of alcohol hand sanitizer as an infection control strategy in an acute care facility. *Am J Infect Control* 2003; 31(2): 109-16.
[<http://dx.doi.org/10.1067/mic.2003.15>] [PMID: 12665745]
- [25] Lam BC, Lee J, Lau YL. Hand hygiene practices in a neonatal intensive care unit: A multimodal intervention and impact on nosocomial infection. *Pediatrics* 2004; 114(5): e565-71.
[<http://dx.doi.org/10.1542/peds.2004-1107>] [PMID: 15492360]
- [26] Won SP, Chou HC, Hsieh WS, *et al.* Handwashing program for the prevention of nosocomial infections in a neonatal intensive care unit. *Infect Control Hosp Epidemiol* 2004; 25(9): 742-6.
[<http://dx.doi.org/10.1086/502470>] [PMID: 15484798]
- [27] Zerr DM, Allpress AL, Heath J, Bornemann R, Bennett E. Decreasing hospital-associated rotavirus infection: A multidisciplinary hand hygiene campaign in a children's hospital. *Pediatr Infect Dis J* 2005; 24(5): 397-403.
[<http://dx.doi.org/10.1097/01.inf.0000160944.14878.2b>] [PMID: 15876937]
- [28] Rosenthal VD, Guzman S, Safdar N. Reduction in nosocomial infection with improved hand hygiene in intensive care units of a tertiary care hospital in Argentina. *Am J Infect Control* 2005; 33(7): 392-7.
[<http://dx.doi.org/10.1016/j.ajic.2004.08.009>] [PMID: 16153485]
- [29] Johnson PD, Martin R, Burrell LJ, *et al.* Efficacy of an alcohol/chlorhexidine hand hygiene program in a hospital with high rates of nosocomial methicillin-resistant *Staphylococcus aureus* (MRSA) infection. *Med J Aust* 2005; 183(10): 509-14.
[PMID: 16296963]
- [30] Pittet D, Boyce JM. Revolutionising hand hygiene in health-care settings: Guidelines revisited. *Lancet Infect Dis* 2003; 3(5): 269-70.
[[http://dx.doi.org/10.1016/S1473-3099\(03\)00601-7](http://dx.doi.org/10.1016/S1473-3099(03)00601-7)] [PMID: 12726970]
- [31] Harrison WA, Griffith CJ, Ayers T, Michaels B. Bacterial transfer and cross-contamination potential associated with paper-towel dispensing. *Am J Infect Control* 2003; 31(7): 387-91.
[<http://dx.doi.org/10.1067/mic.2003.81>] [PMID: 14639433]
- [32] Barker J, Vipond IB, Bloomfield SF. Effects of cleaning and disinfection in reducing the spread of Norovirus contamination via environmental surfaces. *J Hosp Infect* 2004; 58(1): 42-9.
[<http://dx.doi.org/10.1016/j.jhin.2004.04.021>] [PMID: 15350713]
- [33] El Shafie SS, Alishaq M, Leni Garcia M. Investigation of an outbreak of multidrug-resistant acinetobacter baumannii in trauma intensive care unit. *J Hosp Infect* 2004; 56(2): 101-5.
[<http://dx.doi.org/10.1016/j.jhin.2003.09.024>] [PMID: 15019220]
- [34] Sartor C, Jacomo V, Duvivier C, Tissot-Dupont H, Sambuc R, Drancourt M. Nosocomial *Serratia marcescens* infections associated with

- extrinsic contamination of a liquid nonmedicated soap. *Infect Control Hosp Epidemiol* 2000; 21(3): 196-9.
[<http://dx.doi.org/10.1086/501743>] [PMID: 10738989]
- [35] Duckro AN, Blom DW, Lyle EA, Weinstein RA, Hayden MK. Transfer of vancomycin-resistant enterococci *via* health care worker hands. *Arch Intern Med* 2005; 165(3): 302-7.
[<http://dx.doi.org/10.1001/archinte.165.3.302>] [PMID: 15710793]
- [36] Passaro DJ, Waring L, Armstrong R, *et al.* Postoperative *Serratia marcescens* wound infections traced to an out-of-hospital source. *J Infect Dis* 1997; 175(4): 992-5.
[<http://dx.doi.org/10.1086/514008>] [PMID: 9086167]
- [37] Simmons B, Bryant J, Neiman K, Spencer L, Arheart K. The role of handwashing in prevention of endemic intensive care unit infections. *Infect Control Hosp Epidemiol* 1990; 11(11): 589-94.
[<http://dx.doi.org/10.2307/30148433>] [PMID: 2258599]
- [37] McLane C, Chenelly S, Sylwestrak ML, Kirchoff KT. A nursing practice problem: Failure to observe aseptic technique. *Am J Infect Control* 1983; 11(5): 178-82.
[[http://dx.doi.org/10.1016/0196-6553\(83\)90078-0](http://dx.doi.org/10.1016/0196-6553(83)90078-0)] [PMID: 6557774]
- [39] Larson E. Compliance with isolation technique. *Am J Infect Control* 1983; 11(6): 221-5.
[[http://dx.doi.org/10.1016/0196-6553\(83\)90004-4](http://dx.doi.org/10.1016/0196-6553(83)90004-4)] [PMID: 6559546]
- [40] Watanakunakorn C, Wang C, Hazy J. An observational study of hand washing and infection control practices by healthcare workers. *Infect Control Hosp Epidemiol* 1998; 19(11): 858-60.
[<http://dx.doi.org/10.2307/30141567>] [PMID: 9831945]
- [41] Pittet D, Hugonnet S, Harbarth S, *et al.* Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Infection control programme*. *Lancet* 2000; 356(9238): 1307-12.
[[http://dx.doi.org/10.1016/S0140-6736\(00\)02814-2](http://dx.doi.org/10.1016/S0140-6736(00)02814-2)] [PMID: 11073019]
- [42] Muto CA, Sistrom MG, Farr BM. Hand hygiene rates unaffected by installation of dispensers of a rapidly acting hand antiseptic. *Am J Infect Control* 2000; 28(3): 273-6.
[<http://dx.doi.org/10.1067/mic.2000.103242>] [PMID: 10840351]
- [43] Preston GA, Larson EL, Stamm WE. The effect of private isolation rooms on patient care practices, colonization and infection in an intensive care unit. *Am J Med* 1981; 70(3): 641-5.
[[http://dx.doi.org/10.1016/0002-9343\(81\)90588-X](http://dx.doi.org/10.1016/0002-9343(81)90588-X)] [PMID: 7211897]
- [44] Albert RK, Condie F. Hand-washing patterns in medical intensive-care units. *N Engl J Med* 1981; 304(24): 1465-6.
[<http://dx.doi.org/10.1056/NEJM198106113042404>] [PMID: 7248048]
- [45] Mayer JA, Dubbert PM, Miller M, Burkett PA, Chapman SW. Increasing handwashing in an intensive care unit. *Infect Control* 1986; 7(5): 259-62.
[<http://dx.doi.org/10.1017/S0195941700064171>] [PMID: 3635490]
- [46] Graham M. Frequency and duration of handwashing in an intensive care unit. *Am J Infect Control* 1990; 18(2): 77-81.
[[http://dx.doi.org/10.1016/0196-6553\(90\)90085-7](http://dx.doi.org/10.1016/0196-6553(90)90085-7)] [PMID: 2337258]
- [47] Taylor LJ. An evaluation of handwashing techniques-1. *Nurs Times* 1978; 74(2): 54-5.
[PMID: 622326]
- [48] van den Broek PJ, Verbakel-Salmons EMA, Bernards AT. Quantity versus quality of hand hygiene. *J Hosp Infect* 2001; 49(4): 297-8.
[<http://dx.doi.org/10.1053/jhin.2001.1103>] [PMID: 11740882]
- [49] Fridkin SK, Pear SM, Williamson TH, Galgiani JN, Jarvis WR. The role of understaffing in central venous catheter-associated bloodstream infections. *Infect Control Hosp Epidemiol* 1996; 17(3): 150-8.
[<http://dx.doi.org/10.2307/30142373>] [PMID: 8708352]
- [50] Harbarth S, Sudre P, Dharan S, Cadenas M, Pittet D. Outbreak of *Enterobacter cloacae* related to understaffing, overcrowding, and poor hygiene practices. *Infect Control Hosp Epidemiol* 1999; 20(9): 598-603.
[<http://dx.doi.org/10.1086/501677>] [PMID: 10501256]
- [51] Vicca AF. Nursing staff workload as a determinant of methicillin-resistant *Staphylococcus aureus* spread in an adult intensive therapy unit. *J Hosp Infect* 1999; 43(2): 109-13.
[<http://dx.doi.org/10.1053/jhin.1999.0246>] [PMID: 10549310]
- [52] Grundmann H, Hori S, Winter B, Tami A, Austin DJ. Risk factors for the transmission of methicillin-resistant *Staphylococcus aureus* in an adult intensive care unit: Fitting a model to the data. *J Infect Dis* 2002; 185(4): 481-8.
[<http://dx.doi.org/10.1086/338568>] [PMID: 11865400]
- [53] Larson EL, Early E, Cloonan P, Sugrue S, Parides M. An organizational climate intervention associated with increased handwashing and decreased nosocomial infections. *Behav Med* 2000; 26(1): 14-22.
[<http://dx.doi.org/10.1080/08964280009595749>] [PMID: 10971880]
- [54] Survey of hand washing behaviour (trended). Prepared for the American Microbiology Society and the American Cleaning Institute 2010.
- [55] Another U.S. Airport travel hazard-dirty hands. *American Society for Microbiology* 2003.

- [56] Guinan ME, McGuckin-Guinan M, Severeid A. Who washes hands after using the bathroom? *Am J Infect Control* 1997; 25(5): 424-5. [[http://dx.doi.org/10.1016/S0196-6553\(97\)90092-4](http://dx.doi.org/10.1016/S0196-6553(97)90092-4)] [PMID: 9343628]
- [57] Johnson HD, Shollosky D, Gabello KL, Ragni RV, Ogonosky NM. Gender differences in hand washing behaviour associated with visual behaviour prompts. *Percept Mot Skills* 2003; 97(3): 805-10. [<http://dx.doi.org/10.2466/pms.2003.97.3.805>] [PMID: 14738345]
- [58] Judah G, Augner R, Schmidt WP, Michie S, Granger S, Curtis V. Experimental pretesting of hand-washing interventions in a natural setting. *Am J Public Health* 2009; 99(S2)(Suppl. 2): S405-11. [<http://dx.doi.org/10.2105/AJPH.2009.164160>] [PMID: 19797755]
- [59] Pittet D. Improving compliance with hand hygiene in hospitals. *Infect Control Hosp Epidemiol* 2000; 21(6): 381-6. [<http://dx.doi.org/10.1086/501777>] [PMID: 10879568]
- [60] Pittet D. Improving adherence to hand hygiene practice: A multidisciplinary approach. *Emerg Infect Dis* 2001; 7(2): 234-40. [<http://dx.doi.org/10.3201/eid0702.010217>] [PMID: 11294714]
- [61] Voss A, Widmer AF. No time for handwashing! Handwashing versus alcoholic rub: Can we afford 100% compliance? *Infect Control Hosp Epidemiol* 1997; 18(3): 205-8. [<http://dx.doi.org/10.2307/30141985>] [PMID: 9090551]
- [62] Larson EL, Aiello AE, Bastyr J, et al. Assessment of two hand hygiene regimens for intensive care unit personnel. *Crit Care Med* 2001; 29(5): 944-51. [<http://dx.doi.org/10.1097/00003246-200105000-00007>] [PMID: 11378602]
- [63] Boyce JM, Kelliher S, Vallande N. Skin irritation and dryness associated with two hand-hygiene regimens: Soap-and-water hand washing versus hand antiseptics with an alcoholic hand gel. *Infect Control Hosp Epidemiol* 2000; 21(7): 442-8. [<http://dx.doi.org/10.1086/501785>] [PMID: 10926393]
- [64] Larson E. Skin hygiene and infection prevention: more of the same or different approaches? *Clin Infect Dis* 1999; 29(5): 1287-94. [<http://dx.doi.org/10.1086/313468>] [PMID: 10524977]
- [65] Winnefeld M, Richard MA, Drancourt M, Grob JJ. Skin tolerance and effectiveness of two hand decontamination procedures in everyday hospital use. *Br J Dermatol* 2000; 143(3): 546-50. [<http://dx.doi.org/10.1111/j.1365-2133.2000.03708.x>] [PMID: 10971327]
- [66] Lucet J-C, Rigaud M-P, Mentre F, et al. Hand contamination before and after different hand hygiene techniques: A randomized clinical trial. *J Hosp Infect* 2002; 50(4): 276-80. [<http://dx.doi.org/10.1053/jhin.2002.1202>] [PMID: 12014900]
- [67] Pittet D, Dharan S, Touveneau S, Sauvan V, Perneger TV. Bacterial contamination of the hands of hospital staff during routine patient care. *Arch Intern Med* 1999; 159(8): 821-6. [<http://dx.doi.org/10.1001/archinte.159.8.821>] [PMID: 10219927]
- [68] Girou L, Sabrina Loyeau, patrik legrand, francoise oppein brun-buisson. Efficacy of hand rubbing with alcohol based solution versus standard hand washing with antiseptic soap: Randomised clinical trial. *BMJ* 2002; 325: 1-5. [<http://dx.doi.org/10.1136/bmj.325.7360.362>] [PMID: 12098707]
- [69] Weber DJ, Sickbert-Bennett E, Gergen MF, Rutala WA. Efficacy of selected hand hygiene agents used to remove *Bacillus atrophaeus* (a surrogate of *Bacillus anthracis*) from contaminated hands. *JAMA* 2003; 289(10): 1274-7. [<http://dx.doi.org/10.1001/jama.289.10.1274>] [PMID: 12633189]
- [70] Albert RK, Condie F. Hand-washing patterns in medical intensive-care units. *N Engl J Med* 1981; 304(24): 1465-6. [<http://dx.doi.org/10.1056/NEJM198106113042404>] [PMID: 7248048]
- [71] Vahdat K, Rezaei R, Gharibi D. Nosocomial infection in alzahra hospital, boshahr. *Tebbe Jonoub* 2003; 7: 135-40.
- [72] Brunetti L, Santoro E, De Caro F, et al. Surveillance of nosocomial infections: A preliminary study on hand hygiene compliance of healthcare workers. *J Prev Med Hyg* 2006; 47(2): 64-8. [PMID: 17066905]
- [73] Trick WE, Vernon MO, Hayes RA, et al. Impact of ring wearing on hand contamination and comparison of hand hygiene agents in a hospital. *Clin Infect Dis* 2003; 36(11): 1383-90. [<http://dx.doi.org/10.1086/374852>] [PMID: 12766832]
- [74] Khodavaisy S, Nabili M, Davari B, Vahedi M. Evaluation of bacterial and fungal contamination in the health care workers' hands and rings in the intensive care unit. *J Prev Med Hyg* 2011; 52(4): 215-8. [PMID: 22442928]
- [75] Austin DJ, Bonten MJM, Weinstein RA, Slaughter S, Anderson RM. Vancomycin-resistant enterococci in intensive-care hospital settings: Transmission dynamics, persistence, and the impact of infection control programs. *Proc Natl Acad Sci USA* 1999; 96(12): 6908-13. [<http://dx.doi.org/10.1073/pnas.96.12.6908>] [PMID: 10359812]
- [76] Preston GA, Larson EL, Stamm WE. The effect of private isolation rooms on patient care practices, colonization and infection in an intensive care unit. *Am J Med* 1981; 70(3): 641-5. [[http://dx.doi.org/10.1016/0002-9343\(81\)90588-X](http://dx.doi.org/10.1016/0002-9343(81)90588-X)] [PMID: 7211897]

- [76] Simmons B, Bryant J, Neiman K, Spencer L, Arheart K. The role of handwashing in prevention of endemic intensive care unit infections. *Infect Control Hosp Epidemiol* 1990; 11(11): 589-94. [<http://dx.doi.org/10.2307/30148433>] [PMID: 2258599]
- [78] Bischoff WE, Reynolds TM, Sessler CN, Edmond MB, Wenzel RP. Handwashing compliance by health care workers: The impact of introducing an accessible, alcohol-based hand antiseptic. *Arch Intern Med* 2000; 160(7): 1017-21. [<http://dx.doi.org/10.1001/archinte.160.7.1017>] [PMID: 10761968]
- [79] Maury E, Alzieu M, Baudel JL, *et al.* Availability of an alcohol solution can improve hand disinfection compliance in an intensive care unit. *Am J Respir Crit Care Med* 2000; 162(1): 324-7. [<http://dx.doi.org/10.1164/ajrccm.162.1.9908118>] [PMID: 10903262]
- [80] Girou E, Oppein F. Handwashing compliance in a French university hospital: New perspective with the introduction of hand-rubbing with a waterless alcohol-based solution. *J Hosp Infect* 2001; 48(Suppl. A): S55-7. [suppl A]. [[http://dx.doi.org/10.1016/S0195-6701\(01\)90015-5](http://dx.doi.org/10.1016/S0195-6701(01)90015-5)] [PMID: 11759028]
- [81] Pittet D, Dharan S, Touveneau S, Sauvan V, Perneger TV. Bacterial contamination of the hands of hospital staff during routine patient care. *Arch Intern Med* 1999; 159(8): 821-6. [<http://dx.doi.org/10.1001/archinte.159.8.821>] [PMID: 10219927]
- [82] Zaragoza M, Sallés M, Gomez J, Bayas JM, Trilla A. Handwashing with soap or alcoholic solutions? A randomized clinical trial of its effectiveness. *Am J Infect Control* 1999; 27(3): 258-61. [<http://dx.doi.org/10.1053/ic.1999.v27.a97622>] [PMID: 10358229]
- [83] Larson EL, Aiello AE, Bastyr J, *et al.* Assessment of two hand hygiene regimens for intensive care unit personnel. *Crit Care Med* 2001; 29(5): 944-51. [<http://dx.doi.org/10.1097/00003246-200105000-00007>] [PMID: 11378602]
- [84] Larson E. The Association for professionals in infection Control and epidemiology. APIC guideline for hand washing and hand antisepsis in health care settings. *Am J Infect Control* 1995; 23: 251-69. [[http://dx.doi.org/10.1016/0196-6553\(95\)90070-5](http://dx.doi.org/10.1016/0196-6553(95)90070-5)] [PMID: 7503437]
- [85] Cardoso CL, Pereira HH, Zequim JC, Guilhermetti M. Effectiveness of hand-cleansing agents for removing *Acinetobacter baumannii* strain from contaminated hands. *Am J Infect Control* 1999; 27(4): 327-31. [[http://dx.doi.org/10.1016/S0196-6553\(99\)70052-0](http://dx.doi.org/10.1016/S0196-6553(99)70052-0)] [PMID: 10433671]
- [86] Guilhermetti M, Hernandez SE, Fukushigue Y, Garcia LB, Cardoso CL. Effectiveness of hand-cleansing agents for removing methicillin-resistant *Staphylococcus aureus* from contaminated hands. *Infect Control Hosp Epidemiol* 2001; 22(2): 105-8. [<http://dx.doi.org/10.1086/501872>] [PMID: 11232870]
- [87] Wade JJ, Desai N, Casewell MW. Hygienic hand disinfection for the removal of epidemic vancomycin-resistant *enterococcus faecium* and gentamicin-resistant *Enterobacter cloacae*. *J Hosp Infect* 1991; 18(3): 211-8. [[http://dx.doi.org/10.1016/0195-6701\(91\)90145-X](http://dx.doi.org/10.1016/0195-6701(91)90145-X)] [PMID: 1680903]
- [88] Bartzokas CA. A comparison of triclosan and chlorhexidine preparations with 60 per cent isopropyl alcohol for hygienic hand disinfection. *Hosp Infect* 1983; 4: 245-55.
- [89] Ayliffe GAJ, Babb JR, Davies JG, Lilly HA. Hand disinfection: A comparison of various agents in laboratory and ward studies. *J Hosp Infect* 1988; 11(3): 226-43. [[http://dx.doi.org/10.1016/0195-6701\(88\)90101-6](http://dx.doi.org/10.1016/0195-6701(88)90101-6)] [PMID: 2899107]
- [90] Coignard B, Grandbastien B, Berrouane Y, *et al.* Handwashing quality: Impact of a special program. *Infect Control Hosp Epidemiol* 1998; 19(7): 510-3. [<http://dx.doi.org/10.2307/30141402>] [PMID: 9702576]
- [91] Gould D. Nurses' hand decontamination practice: results of a local study. *J Hosp Infect* 1994; 28(1): 15-30. [[http://dx.doi.org/10.1016/0195-6701\(94\)90149-X](http://dx.doi.org/10.1016/0195-6701(94)90149-X)] [PMID: 7806865]
- [92] Lund S, Jackson J, Leggett J, Hales L, Dworkin R, Gilbert D. Reality of glove use and handwashing in a community hospital. *Am J Infect Control* 1994; 22(6): 352-7. [[http://dx.doi.org/10.1016/0196-6553\(94\)90034-5](http://dx.doi.org/10.1016/0196-6553(94)90034-5)] [PMID: 7695114]
- [93] Voss A, Widmer AF. No time for handwashing!? Handwashing versus alcoholic rub: Can we afford 100% compliance? *Infect Control Hosp Epidemiol* 1997; 18(3): 205-8. [<http://dx.doi.org/10.2307/30141985>] [PMID: 9090551]