

Hand rubbing and scrubbing in relation to microbial count among surgical team members in a Saudi Hospital

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Abstract: Background: The surgical team members use different methods of surgical hand antisepsis with the aim of reducing surgical site infections. **Aim:** This study aimed to investigate the effectiveness of povidone iodine hand scrubbing versus alcohol and avagard hand rubbing on reduction of microbial count among surgical team members in a Saudi Hospital. **Methods:** The outcome measure is the number of Colony Forming Units (CFUs) cultured from 10-digit fingertip imprints on agar plates. Seventy two volunteers underwent 3 hand preparation protocols; Protocol (A) included 3 minutes of traditional scrub by PVP-I, protocol (B) involved 3 minutes of hand rubbing, until dry with ethyl alcohol 70%. Protocol (C) included 3 minutes of hand rubbing, until dry with Avagard. Three sets of fingertip imprints were obtained for each group; before rubbing/scrubbing (R/Sc.), immediately after R/Sc., and after glove removal (GR) ie; after 3 hours. **Results:** Results were expressed as the number of CFUs per hand by the use of Log₁₀ RF. No significant difference in baseline hand bacterial load was found before and immediately after hand- R/Sc. procedures among the three groups, while there a significant statistical difference in microbial count after GR (p value = 0.01) and microbial count was lesser by the use of avagard than by the use of other solutions after GR. There was a significant statistical relation between participant's occupation and Count of CFUs(p value = 0.05) and the count found to be decreased among nurses after GR. But there was no significant statistical difference between participant's years of experience and counts of CFUs. Results revealed a significant statistical correlation between performance of rubbing/scrubbing and count of CFUs among the three groups immediately post R/Sc. and after GR. **Conclusion and recommendations:** Surgical hand rub using avagard was significantly more effective in reducing skin colony counts compared to ethyl alcohol 70% and povidone iodine 7.5% and we recommend that avagard hand rubs could be used as a potent hand antisepsis in the operating theatre.

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Key words: Rubbing/ scrubbing (R/Sc.), microbial count, hand hygiene, colony forming units(CFUs), glove removal(GR).

1. Introduction

Surgical site infection (SSI) is a globally recognized problem that results in significant morbidity and mortality, including delayed healing, wound breakdown and sepsis and negative economic impact, including prolonged hospital stays and revision surgery. Hand antisepsis remains a cornerstone of the overall aseptic technique in surgery, to eliminate transient microorganisms and reduce resident skin flora (Lai *et al.*, 2012).

Microorganisms transfer from the hands of health care providers to patients; this is an important factor with regard to health-care associated infections. Skin is a major source of microbial contamination in the surgical environment. Although the scrubbed members of the surgical team are wearing surgical gloves and gowns, their hands and forearms are to be cleaned preoperatively to significantly reduce the number of microorganisms (AORN, 2006).

The hands of surgeons and scrub nurses carry microorganisms identified as sources of microbial contamination. Common organisms causing nosocomial infection are methicillin-resistant *Staphylococcus aureus* (MRSA), *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, members of Enterobacteriaceae and enterococci. *Staphylococcus aureus* and coagulase-negative staphylococci are the leading **causes** of surgical site infections. To help combat this problem, surgical scrubbing is performed to remove or destroy transient microorganisms and reduce resident flora (Asdornwised *et al.*, 2011).

Preoperative hand disinfection by the surgical team is an essential part of the strategy to prevent surgical site infection. To ensure adequate antimicrobial activity, agents for preoperative hand disinfection are required to meet performance standards (Cheeseman *et al.*, 2011). Scrubbing prior to invasive surgical procedures has been an area that has been devoted to great amounts of research.

Unfortunately, after numerous studies, there still no agreed upon regimen for scrubbing prior to entering the operating room. Numerous methods have been used such as the chlorhexidine and povidone iodine scrub brushes, chlorhexidine/ethyl alcohol liquid scrub, and ethyl alcohol alone. Although all have shown some benefits, data shows that there still exists room for improvement (Chertoff & Gonzalez, 2008).

Procedures used by the surgical team to cleanse the hands prior to surgery are intended not only to remove bacteria from the skin initially, an immediate antimicrobial effect, but to maintain a reduction of the microbial skin flora beneath the surgical glove for the duration of the procedure, a persistent antimicrobial effect (Boyce & Pittet, 2002). This performance criterion for immediate and persistent antimicrobial efficacy is recommended by World Health Organization; (WHO, 2009).

Traditional surgical hand antisepsis consists of an aqueous scrub with or without brush, using povidone iodine (PVP-I) or chlorhexidine-based detergents. Some institutions worldwide have recently started using alcohol-based hand rub as an alternative to the traditional aqueous scrub, whilst continental Europe has used such alcohol-based hand rubs for more than 30 years (Asdornwised *et al.*, 2011).

Alcohol-based antiseptic scrub is known to inhibit the growth of resident microorganisms and to reduce the risk of surgical site infection after surgery (Marchand *et al.*, 2008). Hand rubbing with aqueous alcoholic solution has been found to be as effective as a traditional hand scrubbing protocol in preventing 30-day surgical site infection (Parienti *et al.*, 2002). The use of alcohol-based hand scrub is currently the most important infection control measure, and it has significantly reduced the rate of surgical site infections caused by contact with operating room staff (Segal, 2006).

Nurses need to have a proactive voice in the promotion of current best practices for hand hygiene. A multifaceted approaches including a combination of education, written material, intervention, reminders and continued performance feedback, can have an important effect on hand washing compliance and rates of hospital-acquired infection. Nurses can take a leadership role in all healthcare settings to foster an organizational culture that promotes and reflects a strong obligation to patient safety through effective hand hygiene (Jacqueline & Dyan, 2009).

Previous studies compared alcohol rubs with other active compounds (chlorhexidine gluconate, mectronium, zinc) against each other and against aqueous scrubs (chlorhexidine, PVP-I). These found that alcohol hand rubs with additional active compounds were as or more effective than aqueous scrubs at reducing microbial counts of colony forming

units (CFUs) and cost, and have a sustained bactericidal activity. Chlorhexidine's property of adhering to the stratum corneum of the skin allows it to exert a residual antimicrobial effect of up to 6 hours (Gupta *et al.*, 2007). While the current study examined the effectiveness of hand scrub by PVP-I on microbial count compared to hand rub by ethyl alcohol or avagard.

Aim of the study:

This study aimed to investigate the effectiveness of povidone iodine hand scrubbing versus alcohol or avagard hand rubbing on reduction of microbial count among surgical team members in a Saudi Hospital.

2. Material and methods:

Study design:

A quasi- experimental design was utilized in this study.

Study setting:

This study was conducted in operating rooms of King Khalid Hospital a 300-bed general hospital in Najran Region.

Sample:

The study was conducted on 72 volunteers surgical team members working in operating rooms. Criteria for sample selection was included male and female nurses, anesthesiologists and surgeons who a) had prior experience of surgical hand scrub in an operating theatre environment; b) Had no history of chlorhexidine gluconate or alcohol allergy; c) Had no known history of upper limb infections or recent trauma to the fingers and hands; d) Were expected to be available throughout the practical course of the study (3 months). Before the beginning of the practical part of the study, all participants were involved in a training course about scrubbing, rubbing, gowning, and gloving techniques. After that; participants were classified randomly into three groups using the simple random sampling method, each group were involved into one protocol from the three protocols (protocol A, B, and C) of hand disinfection according to type of the used antiseptic agent.

Tools:

A structured interview schedule was developed by the investigators after reviewing the literature, the final form consists of three parts:

Part I: Included questions to obtain socio-demographic characteristics of the study participants such as age, sex, nationality, qualification, occupation and years of experience.

Part II: Hand preparation protocols; it consisted of three protocols:

Protocol A:

This protocol included three minutes of traditional scrub by povidone iodine 7.5% (PVP-I). After general cleansing with neutral soap,

participants commenced a 3-minutes hand scrubbing with 15 ml (3x5ml) of PVP-I. Hands were dried with sterile towels and the initial sets of 2 x 5-digit fingertip imprint were obtained, applying gentle pressure of finger pulps onto 2 blood agar plates (1 plate for each hand) for 5 seconds. Thereafter, gloves were donned using a no-touch technique. After 3 hours, the gloves were removed, also via a no-touch technique. The subsequent sets of 2 x 5-digit imprints were then obtained.

Protocol B:

This protocol involved three minutes of hand rubbing, until dry with ethyl alcohol 70%. Also Cleansing have finished with neutral hand wash. Thereafter, 15ml (3x5ml) of ethyl alcohol 70% was dispensed onto each participant's hands, and covered completely before rubbing commenced. Sterile towels were not required as rubbing continued until solution evaporated and hands were dry. 2 x 5-fingertip imprints were obtained before and after donning and doffing gloves(after 3 hours) respectively.

Protocol C:

In this protocol three minutes of hand rubbing, until dry with Avagard was performed. Similar sequence for protocol B; Thereafter, 15ml (3x5ml) of Avagard (clorahexidine gluconate 2%+ ethyle alcohol 70%) was dispensed onto each participant's hands, and covered completely before rubbing commenced. Also rubbing continued until solution evaporated and hands were dry. 2 x 5-fingertip imprints were obtained before and after donning and doffing gloves respectively (after 3 hours).

Part III: An observational checklist (AORN 2010) which included the following items; scrubbing, rubbing, gowning, gloving, gown and glove removal performance of the study the participants with rating scale completely done (2 marks) incompletely done (1 mark) and not done (0 mark)

Bacteriological techniques:

All agar plates were transported to Microbiology Department, College of medicine Najran University. The plates were incubated upon collection at 37°C. After 48 hours of incubation, colony counts were obtained for all plates. Species identification was not performed because the primary focus is to obtain a quantitative rather than a qualitative analysis. The logarithm of bacterial count (CFU/ml) was presented as means and SD. The log₁₀ reduction factor (RF) was calculated from the difference in the logarithm of bacterial counts before, immediately after and 3 hours after hand disinfection.

Tools validity:

The observational checklist contents were tested for its content validity through five expertise from medical surgical nursing department.

Tools reliability:

Rater agreement for assessment of the observational checklist for scrubbing, gowning gloving and glove removal was 0.78 indicating a reliable checklist.

The pilot study:

A pilot study was conducted in 10% of the study sample (8 surgical team members) to test the clarity and validity of the study tool contents; and members involved in the pilot study were excluded from the study sample.

Administrative and ethical consideration:

An official permission was obtained from hospital medical director as well as nursing director to conduct the study at the operating room during 6-months period from October 2012 to April 2013. Also we obtained a signed informed consent from surgical team members who had a willing to participate in the study.

Statistical analysis:

The collected data were organized, tabulated and statistically analyzed using SPSS software statistical computer package version 15. numbers, percentages, means and standard deviations were calculated. For comparison between two means, the T-test was calculated. For comparison between more than two means, the F value of analysis of variance (ANOVA) was calculated, where LSD test was performed to compare between each two means if F value was significant. Correlation between variables was evaluated using Pearson's correlation coefficient. Significance was adopted at $p < 0.05$ for interpretation of results of tests of significance.

3.Results:

Demographic data and baseline characteristics of the participants were presented in table (1). The study included 72 participants; 30 registered nurses, 24 surgeons and 18 anaesthesiologists. Most of the participants were male(65.3%) and >40 years of age(56.9%). About one third of the participants(34.7%) were Saudi surgical staff; nearly half of them(45.8%) had an experience ranged from 10 to 20 years while the majority of them(55.6%) had a bachelor degree.

In the 3 groups, the relationship of participant's occupation and microbial count before and after rubbing/scrubbing(R/Sc.) was statistically insignificant; while the only statistical difference was found regarding after glove removal (GR)(after three hours of scrubbing). (p value=0.05)(Table 2). By the use of LSD test we found that the significant statistical relation between participant's occupation and mean Log₁₀ RF of CFUs favoring nurses (2.5) (Figure 1); indicated that nurses had less CFUs than surgeon and anesthesiologist.

Among the 3 groups, the relationship of participants' years of experience and mean Log_{10} RF of CFUs before and immediately after rubbing/scrubbing and after glove removal was statistically insignificant (Table 3)

The mean change in CFUs counts by the use of Log_{10} RF before and immediately after hand R/Sc. procedures among the three groups for the 3 used protocols was not statistically significant. The significant changes in CFUs count by the use of Log_{10} RF was found after GR for the 3 used protocols ($P < 0.01$) as shown in table (4). By the use of LSD test

we found a significant statistical relation between microbial count reduction by the use of Log_{10} RF after glove removal and protocol(c) (avagard) as shown in figure (2).

There was a significant statistical correlation between performance of R/Sc., gowning, gloving, gown and glove removal for the three studied groups and the reduction in their CFUs count by the use of Log_{10} RF after R/Sc. and after GR ($P < 0.01$) table (5) illustrated that there is a reversal correlation between scrubbing performance and reduction in microbial count after R/Sc. and after GR.

Table (1): Demographic Data and baseline characteristics of the study participants

Demographic data	Iodine (n=24)		Alcohol (n=24)		Avagard (n=24)		Total (n=72)	
	n	%	n	%	n	%	n	%
Gender								
Female	6	24	10	40	9	36	25	34.7
Male	18	38.3	14	29.8	15	31.9	47	65.3
•Age:								
from 20 to 40	13	41.9	9	29	9	29	31	43.1
Over40	11	26.8	15	36.6	15	36.6	41	56.9
Qualification								
bachelor	15	37.5	12	30	13	32.5	40	55.6
Post graduate	9	28.1	12	37.5	11	34.4	32	44.4
Occupation								
Nurse	9	30	8	26.7	13	43.3	30	41.7
Surgeon	7	29.2	9	37.5	8	33.3	24	33.3
Anaesthesiologist	8	44.4	7	38.9	3	16.7	18	25
Nationality								
Egyptian	4	36.4	2	18.2	5	45.5	11	15.3
Filipinas	4	40	2	20	4	40	10	13.9
Indian	0	0	6	40	9	60	15	20.8
Saudi	13	52	7	28	5	20	25	34.7
Yamani	3	27.3	7	63.6	1	9.1	11	15.3
•years of experiences								
from 1 to less than 10	5	38.5	5	38.5	3	23.1	13	18.1
from 10 to 20	12	36.4	11	33.3	10	30.3	33	45.8
more than 20	7	26.9	8	30.8	11	42.3	26	36.1

Table (2): The mean CFUs count before & after R/Sc. And after GR. according to the participant's occupation

Microbial count	Nurse (n=30)	Surgeon (n=24)	Anaesthesiologist (n=18)	F-test	P
	Mean±SD	Mean±SD	Mean±SD		
Before R/Sc.	4.04± .67	4.18± .64	4.28± .46	.915	.406
After R/Sc.	1.55± 1.81	2.09± 1.99	2.41± 1.81	1.303	.278
After GR.	2.50± 1.71	2.94± 1.81	3.64± .53	3.078*	.05

*Significant ($P < 0.05$)

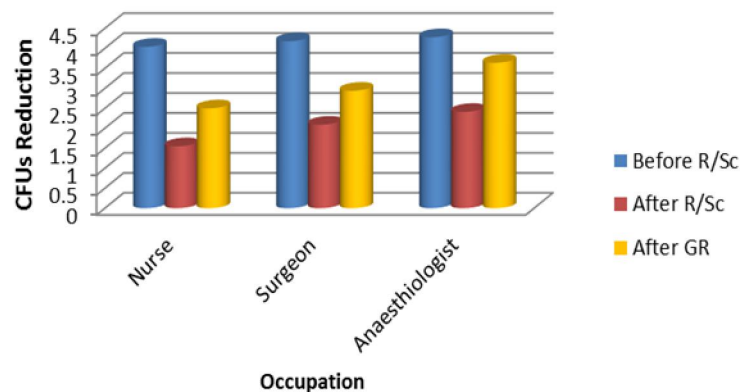


Figure (1): The mean reduction of CFUs count after GR. regarding participant's occupation using LSD test

Table (3): The mean CFUs count before & after R/Sc. and after GR. according to the participant's experience

Microbial count	from 1 to less than 10Y (n=13)	from 10 to 20Y (n=33)	more than 20Y (n=26)	F-test	P
	Mean±SD	Mean±SD	Mean±SD		
Before R/Sc.	4.09± .56	4.13± .70	4.19± .53	.133	.876
After R/Sc.	2.11± 1.78	1.99 ± 1.98	1.79± 1.86	.143	.867
After GR.	3.22± 1.07	2.91± 1.75	2.82± 1.63	.270	.764

*Significant (P<0.05)

Table (4): The mean CFUs count before & after R/Sc. and after GR. regarding the 3 used disinfectants

Microbial count	Iodine (n=24)	Alcohol (n=24)	Avagard (n=24)	F-test	P
	Mean±SD	Mean±SD	Mean±SD		
Before R/Sc.	4.06± .58	4.15± .60	4.23± .67	.443	.644
After R/Sc.	1.96± 1.86	2.27± 2.01	1.59± 1.78	.781	.462
After GR.	2.99± 1.44	3.73± .98	2.07± 1.83	7.746**	.001

**Significant (P<0.01)

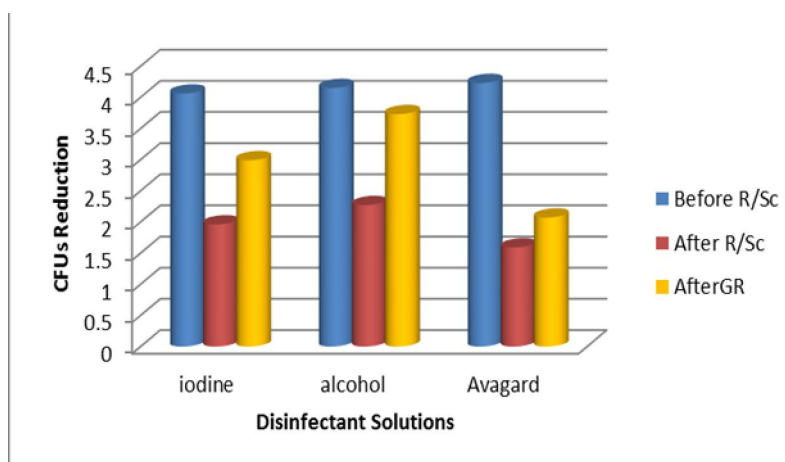


Figure (2): The mean CFUs count before & after R/Sc. and after GR among the 3 used disinfectants using LSD test.

Table (5): The CFUs count of the 3 groups according to their performance using observation checklist

Groups	CFUs	R/Sc.	Gowning	Gloving	GR.
Group A protocol	After R/Sc.	-.826(**)	.094	.282	-.135
	After GR	-.589(**)	.061	.129	-.208
Group B protocol	After R/Sc.	-.787(**)	.157	-.098	.088
	After GR	-.717(**)	.125	.068	.257
Group C protocol	After R/Sc.	-.615(**)	-.251	-.228	.116

** Correlation is significant at the 0.01 level (2-tailed)

4. Discussion:

Alcohol-based hand rubs have been shown to have a better antimicrobial efficacy on both the transient and resident hand flora (Kampf & Kramer, 2004). That is why it has been recommended in the new CDC guideline on hand hygiene that they may be used for surgical hand disinfection (Boyce & Pittet, 2002). The antimicrobial efficacy of alcohol-based formulations is superior to that of all other currently available products for preoperative surgical hand preparation. Several alcohol-based hand rubs have been licensed for the commercial market, frequently with additional, long-acting compounds as chlorhexidine gluconate limiting regrowth of bacteria on gloved hands.

Povidone iodine (PVP-I) 7.5% was selected for the aqueous scrub used in protocol (A) as it was the one of the most commonly used solutions in our operating theatres. Ethyl alcohol 70% was selected for hand rub in protocol (b) because it is known that products with 70% to 80% alcohol generally perform better against microbes than those with less than 70% alcohol and to compare its effect on microbial reduction with the effect of povidone iodine (PVP-I) and Avagard. Avagard was chosen due to its better skin tolerance profile and availability at the time of study. In addition, the more established residual antimicrobial property of chlorhexidine in Avagard compared to PVP-I and alcohol alone mandates that it should be studied during the protocol (C) (Lai *et al.*, 2012).

For contact time with skin, Tanner *et al.* (2008) had suggested that 3 minutes of surgical hand preparation was adequate for both aqueous scrub and alcohol hand rub. This duration was followed in the hand preparation protocols for the three used hand disinfectants. The WHO 2009 guidelines recommended a sequential application of 3 x 5ml of solution for alcohol hand rubs (Lai *et al.*, 2012) which was followed in this study.

Surgical scrub products should be selected based not only on immediate reductions of normal skin flora, but also on ability to maintain reductions beneath the glove and reduce population of micro-organisms that penetrate the glove through a puncture or break (Beausoleil *et al.*, 2012).

Christopher *et al.* (2010) concluded that the development of Avagard, a relatively new preoperative hand antiseptic with moisturizers, presents an innovation that offers comparable or improved antisepsis compared with the traditional hand scrub. Kampf and Ostermeyer (2005) stated that if chlorhexidine gluconate is used in a "leave-on" preparation like Avagard it can be expected that the non-volatile active agent chlorhexidine gluconate remains on the skin and will continue to have antimicrobial activity. In addition, permanent exposure to chlorhexidine salts has been shown to lead to adaptation or even resistance. These results confirm results of the current study which suggested that Avagard is more efficacious in reducing colony counts than PVP-I after glove removal. Other authors (Lai *et al.*, 2012) demonstrated superior efficacy of hand rub over scrub. Also Grabsch *et al.* (2004) found that the alcoholic chlorhexidine regimen demonstrated excellent bactericidal efficacy throughout an operating list, and was superior to povidone-iodine scrubbing in all aspects. whilst Hajipour *et al.* (2006) found aqueous scrub to be more effective than Avagard. Another study done by Ghorbani *et al.* (2012) found no significant difference between the two disinfectant solutions, this study demonstrated that both of the hand hygiene methods; either washing with soap followed by application of an alcoholic hand rub for three minutes, or washing with povidone iodine for six minutes could remove microorganisms from the hands. Either technique decreases the microbial burden of the hands. This result supports the findings of other studies (Tavolacci *et al.*, 2006, Gupta *et al.*, 2007).

Alcohol rubs and combination hand sanitizers are effective at killing some germs on the hands (Kampf and Ostermeyer; 2005). Many clinical studies have shown that alcohol rubs containing two germ killers (i.e., alcohol and chlorhexidine gluconate) are significantly better germ killers than alcohol rubs containing alcohol alone (Hibbard; 2005). Another study performed by Nishimura (2006) indicated that alcohol alone does not have a long-lasting antimicrobial effect. When used in conjunction with persistent antiseptic agents, however, the contained antiseptic exerts a long-lasting bactericidal effect, while the sub-bactericidal concentration of alcohol

suppresses the growth of some bacteria on the hands. These findings are going on line with the results of this study which revealed that avagard is more potent than ethyl alcohol 70% in reducing number of colony forming units after glove removal. This result interpreted by Thomas *et al.* (2000) who reported that the potential benefit of chlorhexidine gluconate is thought to be a prolonged effect. While this result is not compatible with the study done by Boyce and Pittet (2002) who demonstrated that the addition of 1% chlorhexidine gluconate to the 61% ethanol did not provide a substantial improvement of the bactericidal efficacy after 3 hours.

Results of this study indicated that there was no significant statistical difference between the three used disinfectants; PVP-1, alcohol and avagard regarding reduction of colony forming units immediately after scrubbing but the difference found after glove removal (after 3hrs) favoring avagard. These findings is congruent with the results of Bryce *et al.* (2001) who indicated that although there is no significant difference between bacterial colony count of the hands immediately after using alcoholic and other scrubbing solutions like povidone iodine, after two hours this changes significantly. These authors found that staff who had used an alcoholic rub solution showed lower bacterial colony count on their hands. Another research done by Heeg (2001) have demonstrated that formulations containing 60% - 95% alcohol alone, or 50% - 95% when combined with small amounts of chlorhexidine gluconate, reduce bacterial counts on the skin immediately post scrub more effectively than other agents. While another studies reported that alcohol containing hand rubs are also frequently used for pre-surgical disinfection, and are also effective in providing an immediate reduction in skin flora that persists up to 6 hrs beneath a surgical glove (Bryce *et al.*, 2001; Kampf & Kramer 2004; and Kampf & Ostermeyer 2005).

The nurse is the member of the healthcare team who leads the rest of the team in practicing prevention strategies to protect the patient from infection. Some of the most basic strategies resulting in positive patient outcomes include the practice and promotion of hand hygiene (Sandra & Jan, 2011). Looking at figures from the present study, our results revealed that there was a significant statistical relation between participant's occupation and mean Log₁₀ RF of CFUs after glove removal, favoring nurses. But the results of our study showed that there was no statistical relation between participant's years of experience and mean Log₁₀ RF of CFUs. According to our knowledge there was no previous researches correlated neither participant's occupation nor their years of experience to the count of their colony forming units on their fingers.

Findings of the current study indicated that there was a significant statistical correlation between participant's performance of R/Sc, gowning, gloving, gown and glove removal among the three studied groups and the reduction in their mean Log₁₀ RF of CFUs counts after scrubbing and after glove removal. Based on our knowledge, there was no previous studies correlated participant's performance of scrubbing to the count of their colony forming units on their fingers.

Conclusion and recommendations

Our study concluded that hand rubbing with avagard (70% ethyl alcohol+2% clorahexidine gluconate) demonstrated superior efficacy in colony forming units reduction compared to hand rubbing with ethyl alcohol 70% and hand scrubbing with povidone iodine 7.5%. With the results pooled from other authors, we recommend that avagard hand rubs could be included in the operating theatre as a viable alternative to traditional PVP-I surgical scrub for surgical hand antisepsis.

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