



An evaluation of the effectiveness of nursing students' hand hygiene compliance: A cross-sectional study

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ARTICLE INFO

Keywords:

Alcohol-based hand rub
Hand hygiene compliance
Nursing student
Hand washing

ABSTRACT

Background: Hand hygiene is crucial for safe healthcare. Although the use of alcohol hand rubs is encouraged in clinics, there are few studies that focus on the proper use of alcohol hand rubs among nursing students.

Objectives: The aim of this study is to evaluate the effectiveness of alcohol-based hand rub application and proper hand washing techniques which influence nursing students' hand hygiene compliance to make recommendations for future practice of hand hygiene training.

Design: This cross-sectional study was carried out from May 3/June 3 2016 with the participation of 257 nursing students. Their hand hygiene techniques were analyzed using a UV lamp and an alcohol-based mix marked with fluorescence.

Results: Of the participants, 77.0% were first-year students and 55.3% were males. The percentage of skin surface covered by alcohol-based hand rub was 82.0% on both hands. The lowest percentages of skin area covered by fluorescent-labelled hand rub were identified in the metacarpal area near the wrist and thumbs. While there was a difference between points for using proper hand-rub technique on the dorsal and palmar surfaces of the hands ($p < 0.01$), no difference was determined between the right and left hands ($p > 0.05$). It was found that the largest fluorescent remains were on fingers after hand-washing, and there was a difference in terms of hand-washing points between right-left hands and dorsal-palmar surfaces ($p < 0.01$).

Conclusions: There is a need to improve nursing students' compliance with hand hygiene. It is suggested that the use of hand-rub among students should be popularized, and new techniques that prevent the frequently omitted areas of the hands should be integrated into the curriculum.

1. Introduction

Over the last decade, there has been a remarkable increase in epidemics around the world. Healthcare workers form the leading group that is affected by these epidemics. As a large portion of healthcare personnel, nurses have proximity with infected individuals, and this puts them at higher risk of being exposed to contagious diseases (Bernard et al., 2009; Branch-Elliman et al., 2015; International Council of Nurses [ICN], 2016). During the worldwide epidemic of early 2003, healthcare workers accounted for a large proportion of persons with severe acute respiratory syndrome (Park et al., 2004). In recent years, during the Ebola disease outbreak in West Africa, 815 of healthcare workers infected with Ebola and two thirds of them died, > 50% were nurses (ICN, 2016). Also out of the epidemics, healthcare workers were affected by occupational exposures. Kuncio et al. stated that pediatric health workers were often exposed to pertussis due to inadequate infection control measures (Kuncio et al., 2014). From the perspective of

patients, infections stemming from healthcare not only increase their health expenses, but also constitute a significant risk factor for morbidity and mortality (Luangasanatip et al., 2015; World Health Organization [WHO], 2016). More than 2.5 million cases of healthcare-associated infections (HAIs) occur in the Europe, total burden of HAIs in the EU of 501 DALYs per 100,000 people (Cassini et al., 2016), 4.0% of inpatients in U.S. acute care hospitals had at least one HAI (Ray et al., 2015).

On the other hand, it is for sure that hand hygiene (HH) is the most important of all control measures against all infections for both healthcare personnel and patient safety (WHO, 2009; Sax et al., 2007; Allegranzi and Pittet, 2009). World Health Organization suggests that alcohol based handrub (AHR) should be used as the first choice for hand hygiene of nonsoiled hands to safer care. If hands are visibly dirty or when exposure to potential spore-forming organisms, they need to be washed with soap and water (Boyce and Pittet, 2002; WHO, 2009). Despite its ease and extensive regulations on HH, studies show that

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compliance with HH is below the desired level among nurses (Allegranzi and Pittet, 2009; Ward et al., 2014; Azim et al., 2016). The reasons that prevent compliance with HH are: increased care-giving and limited time for hand-washing, hand irritation, allergy to chemicals, insufficient supplies and resources and lack of knowledge, experience and education (Çelik and Koçaşlı, 2008; Hynes, 2015). Compliance with HH practices among nursing students is at lower levels than expectations similar to nurses (Van De Mortel et al., 2012; Nair et al., 2014; Avşar et al., 2015). During clinical applications, due to direct patient contact or contaminant surfaces and devices, both nursing students and their patients are facing increasing the risk of healthcare-associated infections because of lack of knowledge, skills and experience (Çelik and Koçaşlı, 2008; Avşar et al., 2015). Improving the education of nursing students is an effective and sustainable strategy for increasing nurses' compliance with HH. Furthermore, it is important to prevent health care-associated infections.

While AHR are widely used in hospitals, studies that focus on the proper use of AHR are very limited. The aim of this study is to evaluate the factors that influence nursing students' hand hygiene compliance, the use of effective hand-washing techniques, and proper hand-rub application in line with standards.

2. Methods

2.1. Setting

This cross-sectional study was carried out from May 3 to June 3, 2016 with the voluntary participation of 257 first-year and fourth-year students in the department of nursing at Mersin University. The reason choosing this institution was that it was the only public university that provided nursing education in the city as well as it contains many students. Mersin University (MeU) is a state university in Mersin province, Turkey. MeU Nursing Faculty providing undergraduate education took a step to academic life in 1996–1997. The students are admitted to the faculty with the exam conducted by the Higher Education Institution. The students take theoretical lectures and clinical practice (per a week) for seven semesters. They work as intern nurses at the hospital for a final term.

Of a total of 305 first and fourth year students, 28 students did not want to participate to the study, 20 students were not taken to study because of some dermatologic problems on the hands, nail polish and using henna.

2.2. Instrument and Data Collection

The instrument of this study contained three sections. At the first section, the research data were collected using a questionnaire form that included personal data such as age, gender and class, as well as questions about frequently used HH methods, favorite gels or soaps, frequency and duration of washing hands, frequency of contact with patients, frequency of hand-washing in the clinic, washing hands when using gloves and dermatological problems on the hands. This form was prepared by the researchers according to literature (Avşar et al., 2015; Cole, 2009; WHO, 2009; Barrett and Randle, 2008) and filled out by students in the classroom in 10 min.

The second and third sections of this research were carried out in the skills laboratory of the university. Soap and paper towels were provided in the laboratories prior to the experiment. The students were taken to the laboratories in groups of five. One drop of phosphorus (disodium distylylbiphenyl disulfonated, anions) was added to 75 ml hydroalcoholic solution (HAS) (80% ethyl alcohol, 10% prppan-2 ol and glicerine, deionized water) to prepare the AHR solution. Each student was asked to cover her hand with HAS as done in clinics. The students were not informed about the amount of solution to be used or the duration of its application. Each student was given a code number. Using this code, dorsal and palmar images of their right and left hands

were photographed twice with a digital camera. An 50 × 40 cm light-proof black box with room for hands and taking photographs was used to diminish exposure to UV and to ensure better imaging of the fluorescent material. In addition, the room was made dim with curtains.

At the third section of the study, the students were asked to wash their hands according to the antiseptic technique used in the clinic. Then their photographs were taken once again. After the photo-shoot, the students were informed what should be careful about within the stages of the technique of hand-washing by showing them the fluorescent remains on their hands. The participants were asked not to talk to other students who had not yet participated in the research in order to avoid any effect on them. All the stages of this study were carried out by the researchers.

Alcohol-based hand-rub use and the practice of hand-washing were evaluated with the surface area covered by fluorescent material. The UV photographs of students' hands were converted JPEG format for analysis. Measurements taken for each image were made according to blue areas and densities. The study followed these stages to calculate the entire hand surface: distal phalanges (1a, 2a, 3a, 4a, 5a), intermediate-proximal phalanges (1b, 2b, 3b, 4b, 5b) and the areas where the metacarpal (metacarpal I area - close to fingers)- carpal bones, (metacarpal II area - far from the fingers) are located were measured by a tape measure to identify the palmar and dorsal surface of the right and left hands (Fig. 1). The surface of each hand was calculated in terms of cm², and these measurements were later turned into percentages. The dorsal/palmar surface and their percentages were: thumb, 22 cm² 14.5%; 2nd, 3rd, 4th fingers, 40.5 cm², 27%; little finger, 11 cm², 7.5%, metacarpal area near fingers, 36 cm², 24%; metacarpal and carpal area away from the fingers, 40.5 cm², 27%; and the total area, 150 cm², 100%. The projection of 100 was transformed into 1.000 for the convenience of researchers analyzing photographs on the computer. The entire dorsal and palmar surfaces of right and left hands were evaluated out of 4.000 points (Fig. 1). Considering that the percentage distribution of individuals with different hand sizes may vary, measurements were carried out for two men and two women with different hand sizes. Since the difference was only 1%, the same percentage was used for all participants. If the total percentage of all hand surfaces covered with fluorescence was below 75%, disinfectant use was deemed insufficient. For this reason, hand-washing was not calculated for these individuals.

2.3. Statistical Analysis

The data were analyzed using SPSS statistical package program (version 21, New York, USA). Descriptive statistical analyzes (Mean standard deviation, frequency, percentage) were used in the evaluation of the data; Shapiro–Wilk test was used while evaluating normal distribution; independent-samples *t*-test, ANOVA, Mann-Whitney *U* and Kruskal Wallis *H* test were used for normally and non-normally distributed variables, respectively, *p* < 0.05 was accepted as statistically significant.

2.4. Ethical Considerations

Approval was obtained from the Mersin University Clinical Research Ethical Committee (08.04.2016 and 2016/134) and the institution. At the beginning of the study, intervention procedure and details were explained to the students and a written consent was obtained from all of them.

3. Results

The average age of the 257 students participated in the research was 20.54 ± 1.87 years, 44.7% of them were females and 77.1% of them were first-year students. Of the students, 23.3% said that they made direct contact with patients 1 to 5 times a day while this number was 6 to 10 times for 38.9%, 11 to 15 times for 14.8%, and > 15 times for

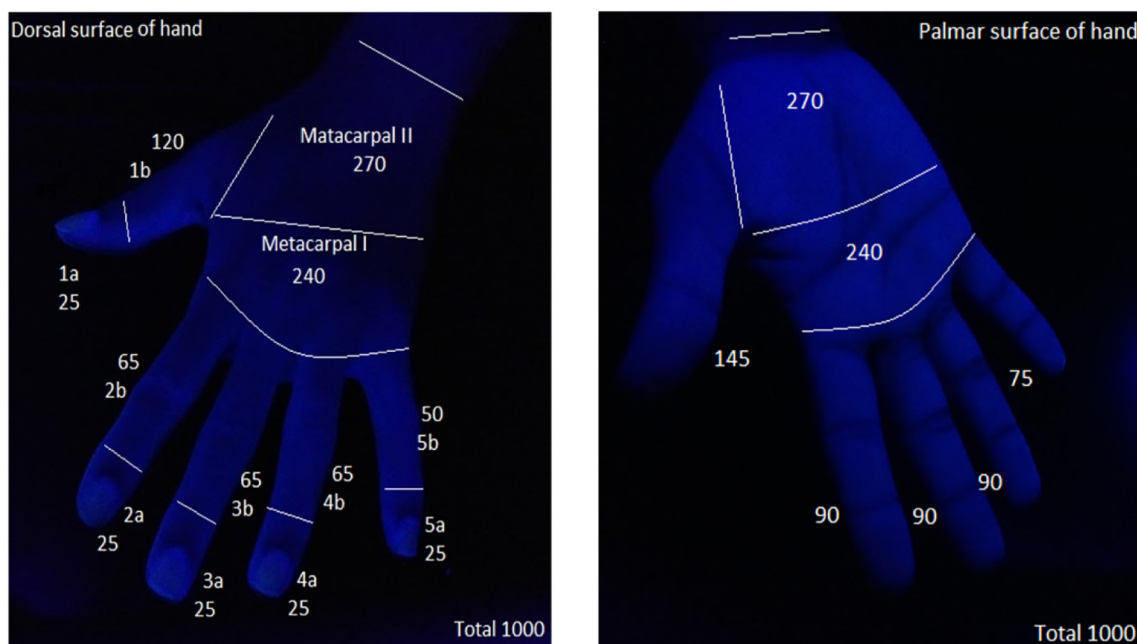


Fig. 1. Evaluation of hand points system images.

23%.

An analysis of the frequency of applying HH in the clinic indicated that 14.8% of the students applied it 1 to 5 times a day, and this number was 6 to 10 times for 32.3%, 11 to 15 times for 23.3%, and > 15 times for 29.6%. The percentage of students who said that they washed their hands to maintain HH was 90.3%, while 8.2% of the students noted that they preferred using antiseptic solution, and 1.6% chose to use gloves. According to the self-statements of students, the duration of hand-washing < 20 s was 20.2%. This rate was 21 to 40 s for 52.9%, 40 to seconds for 19.5%, and longer than 60 s for 7.4%. In addition, 19.8% of the students said that they dried their hands as long as they could, while 0.8% noted that they did not dry their hands at all. Among all students, 3.5% noted that they had dermatological problems on their hands.

Concerning the usage of gloves and hand-washing, 66.9% expressed that they washed their hands before and after wearing gloves; 28% said that they washed their hands only after taking off their gloves, 3.9% did not wash their hands at all; and 1.2% highlighted that they wash their hands before wearing gloves. Besides, 18 students said that it was unnecessary to wash their hands when wearing gloves. The students who stated that they always applied hand-washing procedures constituted 85.6% of the participants, and the percentage of those who did not regularly comply with hand-washing procedures due to limited time was 10.9%. Of the students, 76.8% thought that sufficient supplies and resources (e.g., washrooms) were provided for hand-washing. In addition, 24.9% of the students thought that their hands could dry and their skin could be irritated if they applied hand-washing procedures regularly and 20.6% claimed that washing hands after each patient contact was unpractical.

The analysis of hand antiseptic use found that the percentage of covering both hands with alcohol hand rubs was 82%. The lowest percentages were found on the metacarpal II areas, which are far from the fingers. The percentages of covering the dorsal and palmar surfaces of right and left hands with alcohol-based hand rubs were similar at 74% and 89%, respectively (Fig. 2). The median of AHR use points for the two hands was 3.380 (2960–4000), while it was found 1.710 (1491–1849) for the right hand and 1.695 (1452–1865) for the left. No difference was found between right and left hands in terms of their AHR points ($p > 0.05$). The median of disinfectant use points for the dorsal surfaces of hands was 1.616 (1222–1805) and 1.830 (1688–1945) for palmar surfaces. There was a significant difference between the dorsal

and palmar surfaces in terms of their AHR use points ($p < 0.01$) (Table 1). The practice of hand-washing was not analyzed for 70 people due to their insufficient AHR use (the surface covered with AHR was below 75%).

The analysis of effectiveness of hand-washing found that the percentage of fluorescent traces after hand washing was 55%. The highest percentages were found on the metacarpal I areas, which are close to the fingers. Hand-washing effectiveness decreases as percentages increase. The percentages of hand washing points the dorsal and palmar surfaces of right and left hands were different, right hand points were higher than the left hands' (Fig. 2). Evaluating whether there is a difference between right and left hands in terms of hand washing effectiveness, the median of points for fluorescent remains on hands after washing both hands was found 2.205 (1780–2625), while it was 1181 (955–1384) for the right hand and 1050 (798–1328) for the left ($p < 0.01$). There was a difference between the right and left hand hand-washing points (Table 2). The median of points for washing the dorsal surfaces of the hands was 890 (550–1200) and 1.355 (1010–1595) for palmar surfaces. There was a difference between the dorsal and palmar surfaces hand-washing points ($p < 0.01$) (Table 2).

It was found that the fourth-year male students' AHR use was worse, while effectiveness of their hand-washing was better than the other groups ($p < 0.05$). The female nursing students' AHR points were higher than male students ($p < 0.05$). There was no difference between the use of AHR and the practice of hand-washing by frequency of patient contact ($p > 0.05$) (Table 3).

4. Discussion

Although observation is considered the golden standard in the evaluation of hand-washing, it is also a time-consuming and expensive method (Ward et al., 2014). The proper use of AHR can be analyzed by monitoring the micro-organismic colonization of hands (The Joint Commission, 2009). Unlike these methods, this study used fluorescent material to evaluate hand-washing (Haas and Larson, 2007). This research is significant because it evaluates both the proper use of AHR and effective hand washing techniques.

While there is no observational research analyzing nursing students' compliance with hand-washing procedures, the scholarly literature claims that nursing students' compliance with HH is high based on



Fig. 2. The percentage of distribution of fluorescent-labelled hand-rub and fluorescent traces after hand washing.

nursing students' statements (Snow et al., 2006; Cole, 2009). This research shows that despite such statements effective hand-washing actually remains at low levels. Like the scholarly literature, this research found that the duration of hand-washing is below the standards for a great majority of the students (Avşar et al., 2015). It also pinpoints the lack of education about this matter. Insufficient resources for hand-washing and students' belief in the probable dermatological problems to result from frequent hand-washing may be seen as potential obstacles to the transformation of education into behavioral change.

The findings of this research indicate that approximately only one out of ten students preferred using alcohol hand rubs to ensure HH and one out of every four students used AHR at a significantly insufficient level. Like other studies, these findings are important because students can be a serious source of infections in hospitals (Çelik and Koçaşlı, 2008; Van De Mortel et al., 2012; Kingston et al., 2017). It has been reported that AHR use is more effective than washing hands with water and soap (Boyce and Pittet, 2002; Picheansathian, 2004). Voss and Widmer's study demonstrates that standard practice of washing hands

with water and soap in 100% compliance with HH takes 56 min (Vos and Widmer, 1997). If the same practice is carried out with hand-rub, the duration falls to 18 min. Azim et al. recently showed that this duration is between 9 and 13.5 min in 12-hour shifts (Azim et al., 2016). Disseminating alcohol hand rubs to nursing students who have high frequencies and durations of contact with patients in clinical practices is an appropriate approach to ensuring effective time management in health care.

Although using gloves reduces the possibility of carrying microorganisms on the hands, it cannot substitute for HH. Fuller et al. conducted an observational study that claims using gloves significantly decreases HH practices (Fuller et al., 2011). Like previous studies, our research showed that one of every 20 students found washing hands unnecessary when using gloves (Amin et al., 2013; Ratcliffe and Smith, 2014). Any training for developing hand-washing behavior relies on the adoption of this behavior. This requires changing nursing students' attitudes and eliminating misinformation. Like the scholarly literature, this research found that one of the factors that hinder HH compliance is

Table 1
The point distribution of fluorescent-labelled hand-rub on dorsal and palmar surfaces of right and left hands.

		Thumb		Other fingers								Metacarpal I	Metacarpal II	Total n = 257
		Medyan 25%–75%		Medyan 25%–75%								Medyan 25%–75%	Medyan 25%–75%	Medyan 25%–75%
Right hand	Dorsal	1a*	1b**	2a	2b	3a	3b	4a	4b	5a	5b	200	85	815
		25	100	22	55	25	60	25	60	25	50	140–240	230–260	624–917
	Palmar	15–25	60–110	19–25	35–65	20–25	40–65	20–25	43–65	20–25	40–50	220	240	925
		115		300								200–240	215–270	850–980
Total		82–135		250–335							348–460	460	1710	
		130		90		90		90		75				
Left hand	Dorsal	15–25	60–115	15–25	35–65	20–25	45–65	20–25	45–65	20–25	40–50	130–240	70–270	591–930
		115		305								220	220	830
	Palmar	80–135		253–335								220	240	915
		130		90		90		90		75		200–240	210–270	840–980
Total		117.50–145		0–90		80–90		80–90		70–75				
		240		627							420	440	1695	
Both hands	Dorsal	205–270		560–668							345–460	300–500	1453–1865	
		220		595							400	410	1616	
	Palmar	170–255		495–653							278–460	210–510	1222–1805	
		258		670							440	480	1830	
Total		225–285		625–690							400–480	425–528	1688–1945	
		467		1245							825	866	3380	
		397–520		1128–1315							718–900	650–983	2960–4000	

a* = distal phalanges; b** = Intermediate-proximal phalanges.

the belief that washing hands regularly will dry and irritate hands (Boyce and Pittet, 2002; Van De Mortel et al., 2012). One way to overcome this bias may be to explain students that HAS is less

damaging when used by adding glycerol and similar emollients and should be preferred when there is no visible dirt on hands (Picheansathian, 2004). Showing the students' hand surfaces covered

Table 2
The point distribution of areas fluorescent traces after hand washing.

		Thumb		Other fingers								Metacarpal I	Metacarpal II	Total n = 187
		Medyan 25%–75%		Medyan 25%–75%								Medyan 25%–75%	Medyan 25%–75%	Medyan 25%–75%
Right hand	Dorsal	1a*	1b**	2a	2b	3a	3b	4a	4b	5a	5b	90	60	455
		15	60	15	35	15	30	15	10	15	45	50–150	0–135	290–635
	Palmar	15–20	35–85	15–20	20–50	15–22	15–50	15–22	30–45	15–22	35–50			
		75		204								160	190	720
Total		52–102		135–255							120–200	120–230	540–850	
		105		70		70		70		60				
Left hand	Dorsal	70–125		55–80		55–80		50–80		40–70				
		175		465							260	250	1181	
	Palmar	145–215		395–540							190–320	170–350	955–1384	
		15	45	15	30	15	30	15	30	15	30	90	40	400
Total		15–20	25–80	15–20	10–45	15–20	10–45	15–20	10–45	15–20	10–40	30–140	0–150	211–621
		65		190										
Both hands	Dorsal	45–95		105–250										
		100		70		70		60		50		150	180	655
	Palmar	60–125		50–80		45–80		40–80		30–70		110–200	90–210	460–792
		160		415								240	230	1050
Total		125–195		335–510							170–300	130–330	798–1328	
		153		382							180	135	890	
Both hands	Dorsal	110–185		264–491							90–290	30–280	550–1200	
		195		505							310	360	1355	
	Palmar	145–240		380–615							240–380	240–430	1010–1595	
		335		875							500	480	2205	
Total		275–400		719–1010							380–620	340–630	1780–2625	

a* = distal phalanges; b** = Intermediate-proximal phalanges.

Table 3
The distribution of hand antiseptic use and hand-washing points according to different characteristics.

	The point distribution of surfaces covered with alcohol based hand rub			The point distribution of surfaces covered with fluorescence traces after hand-washing		
	n	Median (25%–75%)	p	n	Mean (Ort. ± ss)	p
Students						
First-year	198	3430.00 (1644.00–4000.00)	0.05	146	2250.94 ± 557.81	0.02
Fourth-year	59	3210.00 (2958.00–3593.00)		41	2002.00 ± 754.78	
Gender						
Male	142	3284.50 (1644.00–3949.00)	0.01	92	2228.22 ± 642.74	0.49
Female	115	3489.00 (1810.00–4000.00)		95	2165.51 ± 584.47	
Patient contact frequency (days/times)						
1–5	60	3364.5 (2920.50–3648.50)	0.33	44	2119.91 ± 467.54	0.34
6–10	100	3410.00 (2828.75–3622.50)		69	2251.68 ± 641.94	
11–15	38	3378.50 (2834.25–3641.25)		25	2335.80 ± 673.92	
> 15	59	3406.00 (3114.00–3692.00)		49	2115.95 ± 650.25	

with fluorescent traces and informing them about micro organismic colonization on surfaces that are not covered with fluorescent remains could be an effective education tool for overcoming the deficiencies in HAS and developing a positive attitude towards HH (Picheansathian, 2004; Škodová et al., 2015).

We think that insufficient use of AHR as well as low use effectiveness may be related to a problem with the amount of AHR used by students. It has been reported that AHR use in HH is influenced by characteristics such as the type of solution, duration of contact and the amount used (Kampf et al., 2008; Zingg et al., 2016). In our research, the students used AHR—just like in the clinic—in the amounts they chose for themselves. The researchers did not interfere in this matter. The WHO (2009) describes standard hand-washing without identifying any particular amount. It suggests that alcohol-based hand scrub should be used to cover the entire hand surface, and that the hands should be scrubbed for 20–30 s. The WHO recommends washing hands according to standard procedures with water and soap for 40–60 s when there is visible dirt on hands. Although the European Centre for Disease Prevention and Control suggests 30 s of hand-washing, there are studies showing the insufficiency of this duration for HH (Kampf et al., 2008; Zingg et al., 2016).

Škodová et al. used a technique similar to ours to evaluate the effectiveness of the HH practices of medical school and nursing school students (Škodová et al., 2015). They analyzed HH practices in five areas (palm, dorsum of the hand, interdigital area, fingers and finger tips) using a five-point scaling system from very sufficient to insufficient. If two of the five areas were not covered with AHR, it was deemed insufficient. If three or more areas were not covered, it was defined as poor AHR use. In our research, if the area covered with disinfectants was below 75%, it was deemed insufficient disinfectant use. The rates of AHR use were higher in our study, notwithstanding the differences between the analyses.

The scholarly literature stresses that hand scrub technique robustly influences the antimicrobial effect (Widmer and Dangel, 2004). Hautemanière et al. found a negative relationship between covering the hands with sufficient HAS and the number of bacteria on the hands (Hautemanière et al., 2009). For this reason, it is important to cover the entire hand with AHR in the appropriate way.

Škodová et al. showed that the distribution of fluorescent traces was the highest on the right and left hand palms and lowest on the thumbs. Our research findings do not indicate any difference between right and left hands in terms of disinfectant distribution. Like Škodová et al. and Hautemanière et al., palmar surfaces were covered with HAS in a more appropriate way than dorsal surfaces (Hautemanière et al., 2009; Škodová et al., 2015). This may stem from the amount of solution used (Kampf et al., 2008; Zingg et al., 2016). Zingg et al. noted that 2 ml of AHR may be sufficient for palmar surfaces of medium and large hands, but not enough for dorsal surfaces (Kampf et al., 2008). As Škodová et al. show, our finding that men's hands were covered with less HAS may be due to their hand sizes. In this research, the lowest points for dorsal surfaces of both hands were identified on surfaces near the wrist and thumbs. In curricula, students should be informed about hand antiseptic use and the practice of hand-washing in line with the WHO's regulations. Although the WHO suggests an 8-stage regulation of hand disinfectant use, Kampf et al. have proposed a new and less detailed 5-stage technique. This new rub-in technique, which aims to prevent the omission of frequently missed surfaces in HH, may be considered as an alternative technique to the WHO's regulations. Thumbs are cleaned in the later stages of the WHO's regulation, while Kampf et al. does so in the third stage. The right palm is described in the third stage of the WHO's regulation. Yet, here it is possible to omit the surface near the wrist. In the fourth stage of the new technique, both the dorsum of the hand and wrists may be covered with disinfectant by positioning and scrubbing the palmar surface of one hand to cover the metacarpal surface on the wrist of the other hand (Kampf et al., 2008). However, there is a need for comparison of both techniques' efficacy.

The findings of this research indicate that first year students' hand disinfectant use was higher than that of fourth year students. Amin et al. claimed that medical students' compliance with HH is insufficient, despite their knowledge (Amin et al., 2013). This may arise from the effects of social learning. Differing HH practices observed in clinics may be confusing for students (Barrett and Randle, 2008).

When the findings about hand-washing were evaluated, a difference was identified between points for washing right and left hands. Avşar et al., observed that students did not use the proper technique to wash their palms (Avşar et al., 2015). Our observation that there were more fluorescent traces on palms and surfaces near the wrist leads to the idea that the new technique of Kampf et al. may be effective for the practice of hand-washing, too.

Like our research, the scholarly literature reports that using fluorescent material is generally effective and may be used as a training tool for HH compliance (Picheansathian, 2004; Hautemanière et al., 2009). In contrast, Miller's research findings indicate that the use of Glo Germs (the fluorescent that was used in that study) may be inappropriate for determining the effectiveness of hand-washing. They also show that there is no significant relationship between bacterial colonization and the amount of Glo Germs that remain on the hands. This may be related to the fact that analysis took place in daylight. It is not possible to identify the boundaries of fluorescent traces on the hands without dimming the environment. Therefore, appropriate arrangement of the environment is significant for accurate analysis (Hautemanière et al., 2009).

5. Conclusion

The study results show that, using fluorescence-marked AHR can be considered as a good choice in evaluating compliance with alcohol-based HH. The type of AHR, duration of contact, the amount used and new techniques in AHR use can increase the efficacy of HH. Presenting a guide for AHR use near the sinks in clinics may reduce the knowledge gap in HH compliance.

6. Limitations of the Study

First, although our study presents useful information about the problems on HH, it does not replace practices at hospitals or direct observation. Second, our research did not consider the ingredients, amount and drying duration of AHR. While the inability to evaluate photographs in three dimensions and the need for experienced observers bring certain limitations to this study, HH training with fluorescence is a preferable and cheaper technique that is also easy to learn for students. This limit may be exceeded with evaluation being made by taking a video to make three-dimensional evaluation.

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