The impact of demographic factors on quality and microbiological effectiveness of hand hygiene among healthcare workers

Wpływ czynników demograficznych na jakość i skuteczność mikrobiologiczną procedury higienicznej dezynfekcji rąk wśród personelu medycznego

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Wprowadzenie. Zakażenia szpitalne, to zakażenia występujące u pacjenta w wyniku procesu opieki w szpitalu lub innym zakładzie opieki zdrowotnej, które nie były obecne ani nie były w okresie wylęgania w momencie przyjęcia. Higiena rąk odgrywa kluczową rolę w zapobieganiu zakażeniom szpitalnym.
Cel. Ustalenie czy czynniki demograficzne wpływają na jakość i skuteczność mikrobiologiczną higieny rąk wśród personelu medycznego.
Materiały i metody. W badaniu wzięło udział 200 pracowników służby zdrowia. Metody obejmowały: kwestionariusz, wizualizację dezynfekowanych rąk w świetle UV, badanie mikrobiologiczne rąk przed i po dezynfekcji.
Wyniki. Kolonizacja bakteryjna po dezynfekcji dłoni różniła się w zależności od doświadczenia zawodowego (p = 0,03). Stwierdzono tendencję rosnącej skuteczności higieny rąk wraz z wiekiem. Pielęgniarki dezynfekowały ręce niemal 2,5 razy częściej niż lekarze. Stwierdzono istotne różnice w kolonizacji bakteryjnej rąk pracowników OIT. Najczęściej pomijanymi obszarami podczas dezynfekcji dłoni (widocznymi w lampie UV) były opuszki palców i wały paznokciowe (46%), podstawa kciuka (37%).
Wnioski. Powtarzające się szkolenia w zakresie higieny rąk są konieczne w celu poprawy jakości i skuteczności procedur higieny rąk.
Słowa kluczowe: higiena rąk, personel medyczny, dezynfekcja, czynniki demograficzne, jakość

Introduction. Healthcare-associated infections (HCAIs) are defined as infections occurring in a patient during the process of care in a hospital or other healthcare facility, which was not present or incubating at the time of admission. Hand hygiene plays a key role in the prevention of HCAIs.
Aim. To define if demographic factors affect the quality and microbiological effectiveness of hand hygiene among healthcare workers.
Material and method. In the study participated 200 healthcare workers. The methods included: questionnaire, disinfected hands' visualization in UV-light, microbial examination of hands before and after disinfection.
Results. Bacterial colonization after hand rub differed according to work experience (p=0.03). An increasing tendency in effectiveness of hand hygiene with age was found. The nurses declared to disinfect hands nearly 2.5 times more frequent than medical doctors. The differences were found in the colonization of ICU workers hands. The most often omitted regions during hand rub (seen in the UV lamp) were fingertips and nail folds (46%), the base of the thumb (37%).
Conclusion. The repeated training in hand hygiene is required to improve the quality and effectiveness of hand hygiene.
Key words: hand hygiene, health care workers, disinfection, demographic factors, quality

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Introduction

Healthcare-associated infections (HCAIs) are defined as infections occurring in a patient during the process of care in a hospital or other healthcare facility, which was not present or incubating at the time of admission. Undoubtedly, HCAIs have a negative impact on the patients' recovery process, may result in prolonged hospitalization or long-term disability, increase resistance of microorganisms to antimicrobials, and elevate hospital mortality and morbidity [1, 2]. It is estimated that in European Countries HCAIs affect 4.6 to 9.3% of hospitalized patients [1].
The crucial role in the prevention of HCAIs is cutting possible routes of transmission. The microorganisms may spread easily in a hospital environment on the hands of healthcare workers (HCW), therefore hand hygiene with

an alcohol-based hand rub performed by medical staff plays a key role in the prevention of HCAIs or colonization with multi-antibiotic resistant microorganisms [2, 3]. This simple procedure should be performed before touching the patient, before clean or aseptic procedures, after body liquid exposure risk, after touching a patient, and after contact with a patient's surroundings. Hand disinfection in these situations is recommended for all HCWs and is known as '5 moments for hand hygiene' [1, 3]. Although the use of hand rub is simple and requires only a few seconds, most HCWs disinfect their hands less than half as often as they should, or perform it improperly [3]. It is estimated that the adherence of HCWs to the recommended hand hygiene procedures is poor, with mean baseline rates of 5 to 81% [4]. Several factors have been described that influence compliance with hand hygiene. The factor that especially affects microbiological effectiveness of the hand rub is an improper way of hand disinfection (insufficient amount of disinfectant, inappropriate duration, or technique) [4]. Recent research suggest that demographic factors may also con-tribute to poor adherence to the recommendations, for instance male gender, type of HCW, shift, job seniority, or hospital area [4, 5].

Aim

To define if demographic factors affect the quality and microbiological effectiveness of hand hygiene among healthcare workers. To assess whether the risk of hand or nail colonization with specific bacteria groups or species differs according to demographic factors. In particular, the focus was on non-modifiable factors such as gender, age, and those related with work experience, especially job seniority, type of job and hospital ward.

Material and method

The study was conducted among a group of 200 healthcare workers (medical doctors and nurses) from 8 hospitals located in the south-west region of Poland (Lower-Silesia and Opol-skie) from October 2013 to November 2013. The participants in the study group were randomly selected. The study was approved by Bioethics Committee at Wroclaw Medical University, with the consent No. KB – 475/2013.

Demographic data were obtained with the use of a short questionnaire. A microbial examination of the participants' hands before and after disinfection was performed. Pre- and post-disinfected hand prints, and samples from beneath the nails were collected and transported to the laboratory within 2 hours. Then they were incubated and analyzed to determine CFU/1 cm2 for hands and CFU/1 ml for nails. Isolated strains were identified using appropriate tests. In addition, a technique of hands visualization in UV-light was applied.

Statistical analysis was conducted in Excel and STATISTICA 12. To determine the potential impact of demographic factors on the level of CFU on hands and nails before and after hand disinfection ANOVA tests were used. To assess the risk of hand or nail colonization with specific bacteria groups or species according to demographic factors, logistic regression models of Bernoulli distribution were applied.

Results

1. Characteristics of the participants of the study

The participants were hospital nurses and doctors who agreed to take part in the study (the condition was the Head of the hospital agreed to participate in the study). The participants included 138 nurses (69%) and 62 doctors (31%). The study group consisted 168 females (84%) and 32 males (16%). They were employed in the following departments: Intensive Care Unit (ICU) – 84 (42%), neurological – 23 (22.5%), surgical – 31 (15.5%), lung diseases – 15 (7.5%), orthopedic – 8 (4%), neonatological – 6 (3%), gynecological-obstetrics – 6 (3%), pediatric – 3 (1.5%), emergency – 1 (0.5%) and operating block – 16 (8%). For the purpose of statistical analysis the participants were divided into groups working in the children's' wards (pediatric, neonatological) – 9 (5%), surgical wards (surgical, operating block, gynecology-obstetrics, emergency, orthopedic) – 62 (31%), non-surgical wards (neurological, internal, lung diseases) – 44 (22%) and ICU – 84 (42%).

Work experience in the studied group was an average of 19 years, the shortest working time in the profession was 3 months and the longest – 42 years. The study was divided into three groups based on seniority (work experience): <5 years of practice (n=29; 14.5%), between 5-15 years of work experience (n=35; 17.5%), over 15 years (n=136; 68%). It has been assumed that a person with less than 5 years of experience is an inexperienced employee in the profession, an employee with seniority between 5-15 years is an employee with professional experience who already has knowledge and habits in the field of hand hygiene. An employee with seniority over 15 years is a person with the most professional experience, with established habits, but at the same time they are an employee who may have outdated information about the rules of hand hygiene in hospital conditions, if they do not participate in training regularly.

2. Gender

Our study showed no differences among males and females between the number of CFU/1 cm2 on hands and the number of CFU/1 cm2 under the nails before and after hygienic hand disinfection (Table I), neither in the amount of CFU logarithmic reduction on hands and nails (Table II), which is the best parameter showing the effectiveness of hygienic disinfection. It was observed that the mean number of CFU on hands and nails before and after hand disinfection was lower among females than males, however these results were statistically insignificant.

The analysis of specific groups and species of bacteria colonizing HCW's hands revealed that the identification of both Gram-positive and Gram-negative bacteria (including Enterobacteriaceae bacilli and non-fermenting bacilli) before and after hand disinfection occurred among a comparable percent of males and females HCW's. Similarly with Gram-positive round-shaped bacteria, with the difference reported only in the case of carriers of Staphylococcus aureus before and after hand disinfection among males (respectively 31 and 16%) and among females (respectively 21 and 9%). Gram-negative bacilli colonized female hands and nails more frequently than male.

The declared frequency of hygienic procedure performance at work and at home according to gender was also analyzed. There was a visible tendency to choose hand disinfection instead of hand washing at work among both females and males. In general, the number of declared performed hygienic procedures at work and at home was higher among female HCWs.

3. Age and work experience

Potential factors that may have an impact on quality and microbiological effectiveness of hygienic procedures among HCWs can be age or work experience. The age of

the participants differed between 23 to 66 years old. For the statistical analysis we divided the study group into three age-groups: <30 years (n=30; 15%), 30-50 years (n=129; 64.5%), and >50 years (n=41; 20.5%). Average work experience was 19 years, with minimal 3 months to maximal 42 years. According to work experience healthcare workers were also divided into three groups: <5 years (n=29; 14.5%), between 5-15 years (n=35; 17.5%), and more than 15 years (n=136; 68%). We assumed that medical staff working less than 5 years was inexperienced, while working more than 15 years was connected with the greatest work experience and consolidated hygienic habits. However, lack of up-to-date knowledge of hand hygiene recommendations and techniques can be a potential problem in the last group, if regular theoretical and practical training are not provided. Therefore, it can negatively affect the quality of hygienic hand disinfection among the most experienced HCWs.

Our study failed to prove a correlation between HCWs' age and microbial colonization of hands before disinfection (p=0.88), or CFU level after hand disinfection (p=0.83). A statistically significant difference in bacterial colonization after hand disinfection according to work experience was observed (p=0.03). In particular, the difference was between the group who worked more than 5 years but less than 15 and those who worked for at least 15 years (p=0.01). Work experience above 15 years was correlated with lower CFU levels on hands after disinfection.

Analysis of the risk for hand and nail colonization with specific bacteria groups and species showed no significant differences according to age, with the exception for the presence of Staphylococcus aureus before disinfection, which was significantly higher among workers at the age of 40 years or more (p=0.01). In contrast, longer work experience (>10 years) was related with lower colonization of Gram-positive cocci on hands before hand disinfection (p=0.01).

No statistically significant differences in the reduction of CFU level on hands and nails ac-cording to age were found, however, an increasing tendency in effectiveness of hand hygiene with age was observed (Table III).

Additional analysis among two age groups (under and over 40 years old) was performed and revealed a statistically significant difference (p=0.01) in the reduction of CFU levels among HCWs under and over 40 years old, with a higher reduction among those over 40 (Table IV). Similarly, work experience over 10 years was connected with a better reduction of CFU levels on hands (p=0.04), as illustrated in Table V.

4. Type of HCWs' profession

The assessment of the potential impact of HCWs' profession on hand hygiene procedures was performed with the use of such parameters as declared frequency of hand washing and hand disinfection at work, mean CFU levels on hands and nails before and after hand disinfection, and reduction of CFU levels on hands and nails. Although nurses declared nearly 2.5 times more frequent hand disinfection than medical doctors, the differences in effectiveness of hand hygiene were not related with type of HCWs' profession (Table VI and VII).

The potential impact of type of job and risk for hand and nail colonization with bacteria groups and species was examined, and demonstrated a lower risk of Gram-positive cocci presence on hands before disinfection among nurses in comparison to doctors.

5. Place of work (hospital wards)

As participants of our study worked in different hospital departments, we investigated potential correlations between working in a particular hospital ward and the effectiveness of hand disinfection. For the analysis we divided HCWs into 4 groups according to workplace:

operative wards: surgical, gynecological, obstetric, orthopedic, Operating Rooms; non-operative wards: internal, pulmonological, neurological, pediatric (including neonatological wards); ICU.

There were no statistically significant differences in mean CFU levels on hands and nails be-fore and after hand disinfection depending on the type of workplace. However, comparison of HCWs of ICU to others (remaining three groups treated as one) demonstrated that work in ICUs was related with a decrease in CFU number on hands before disinfection (p=0.03), but CFU reduction level in this group was lower (p=0.04). We also observed that CFU level on hands and nails after disinfection was lower among those who worked in ICUs, although this tendency was statistically insignificant (p=0.19). The results are shown in Table VIII and IX.

The type of ward had an impact on the presence of different bacteria species on hands and nails before and after hand disinfection. The presence of Gram-positive cocci, including Staphylococcus aureus beforehand disinfection was identified less frequently among medical personnel working in ICU (p=0.046 and 0.033). In contrast, nail colonization with non-fermenting bacilli after disinfection was more frequent in ICU workers (p=0.049).

6. Effectiveness of hand hygiene in UV light

Additional visualization of areas missed during hand disinfection was performed with the use of UV light. We assumed that if hands were evenly covered with disinfectant (they glow uniformly), hand hygiene had been correctly performed. This observation demonstrated that optimal effect in UV light was achieved in 60% of doctors and 60% of nurses. Surprisingly, we failed to prove that there are differences in CFU level on hands and nails after hand disinfection, or in CFU reduction level, between hands evenly covered with alcohol hand rub and hands with missed areas, as these were statistically insignificant.

The most often omitted regions during the use of hand rub (unlit in the UV lamp) were finger-tips and nail folds (46%), and at the base of the thumb (37%). The frequency of skipped places on the backs of the hands was much lower and amounted to 8%, while 3% of HCWs omit-ted the inner parts of the hands, and only 6% of errors concerned the interdigital space.

Table I. Number of CFU on hands and nails before and after hand disinfection according to gender

		HCWs gender N=200		p
		Female N=168	Male N=32	
Mean number of CFU on hands	before hand disinfection	373.17±433.71 CFU/100 cm^2	451.13±421.33 CFU/100 cm^2	0.35
	after hand disinfection	175.48±391.54 CFU/100 cm^2	255.25±497.92 CFU/100 cm^2	0.32
Mean number of CFU on nails	before hand disinfection	34345.24±78295.84 CFU/1 ml	63375.00±105930.62 CFU/1 ml	0.07
	after hand disinfection	18172.62±55781.35 CFU/1 ml	37656.25±93195.23 CFU/1 ml	0.11

Table II. CFU reduction among males and females

	HCWs gender N=200		p
	Female N=168	Female N=168	
Mean CFU reduction on hands	-0.70±0.90	-0.56±2.0	0.97
Mean CFU reduction on nails	-0.71±1.19	-0.40±0.68	0.91

Table III. CFU reduction level among three age groups

	HCWs age groups N=200			p
	<30 years old N=30	30-50 years old N=129	>50 years old N=41	
Mean reduction of CFU level on hands	-0.50±0.84	-0.67±0.95	-0.93±0.99	0.42
Mean reduction of CFU level on nails	-0.17±2.01	-0.58±2.03	-0.63±1.79)	0.35

Table IV. CFU reduction level among HCWs under and over 40 years old

	HCWs age group N=200		p
	<40 years old N=64	≥40 years old N=136	
Mean reduction of CFU level on hands	-0.41±0.84	-0.84±0.98	**0.01**
Mean reduction of CFU level on nails	-0.20±2.07	-0.70±1.92	0.09

Table V. CFU reduction level among HCWs with work experience of less than 10 years and more than 10 years

	HCWs work experience N=200		p
	<10 years N=45	≥10 years N=155	
Mean reduction of CFU level on hands	-0.44±0.83	-0.78±0.98	**0.04**
Mean reduction of CFU level on nails	-0.28±2.10	-0.61±1.94	0.33

Table VI. Mean CFU number on hands and nails according to HCWs' profession

		HCWs profession N=200		p
		Medical doctor N=62	Nurse N=138	
Mean number of CFU on hands	before hand disinfection	432.39±469.83 CFU/100 cm^2	364.61±416.68 CFU/100 cm^2	0.31
	after hand disinfection	241.03±487.74 CFU/100 cm^2	164.52±373.37 CFU/100 cm^2	0.23
Mean number of CFU on nails	before hand disinfection	50870.97±102410.37 CFU/1 ml	33652.17±74440.46 CFU/1 ml	0.18
	after hand disinfection	21193.55±70184.73 CFU/1 ml	21333.33±61037.06 CFU/1 ml	0.99

Table VII. CFU reduction level according to type of profession

	HCWs profession N=200		p
	Medical doctor N=62	Nurse N=138	
Mean reduction of CFU level on hands	-0.62±1.09	-0.73±0.89	0.45
Mean reduction of CFU level on nails	-0.60±2.19	-0.51±1.88	0.77

Table VIII. CFU on nails before and after disinfection in the group of individuals with and without nail polish or conditioner

		Nail Polish or Nail conditioner N=200		p
		With nail conditioner/polish N=4	Without nail conditioner/polish N=196	
Mean number of CFU on nails	before hand disinfection	55000.00±101127.28 CFU/100 cm^2	37096.59±82075.76 CFU/100 cm^2	0.34
	after hand disinfection	52043.48±124192.47 CFU/100 cm^2	17392.05±50521.51 CFU/100 cm^2	0.01

Table IX. CFU reduction on hands and nails depending on the presence of nail polish or conditioner

		Nail Polish or Nail conditioner N=200		p
		With nail conditioner/polish N=4	Without nail conditioner/polish N=196	
Mean reduction of CFU level on hands	before hand disinfection	-0.69±0.94	-0.81±1.08	0.56
Mean reduction of CFU level on nails	before hand disinfection	-0.57±2.05	-0.28±1.30	0.51

Discussion

Demographic characteristics, such as gender and age, have only been described in a few re-search studies. Our findings showed no differences according to sex neither in the number of CFU/1 cm2 on hands or under nails before and after hygienic hand disinfection, nor in CFU logarithmic reduction on hands and nails. Our analysis revealed that the microbiologic effectiveness of using a hand rub was higher among HCWs aged 40 years old. In contrast, Hautemaniere's et al., did not show the difference between various age groups, however their study revealed that males were more likely to have inadequate technique than females [6]. In the literature it has been pointed out that not only age of HCWs may influence hand hygiene practices, but also job seniority in particular. Our observations indicate that work experience over 10 years was related with better reduction of CFU levels on hands. This corresponds with Buffet-Bataillo et al., who identified job seniority as an independent predictor of hand hygiene compliance [5].

Several studies indicate that type of profession is another factor affecting hand hygiene practice. Most have reported that the group of healthcare workers with the highest compliance rates were nurses in comparison to doctors or other HCWs groups [6-12]. Although our study failed to prove that the effectiveness of hand hygiene varies according to type of profession, it has demonstrated that the risk of Gram-positive cocci presence on hands before disinfection was lower among nurses than doctors. These findings are in contrast to Fagernes and Lingaas results, which showed that the hand's colonization with Gram-positive cocci was more frequent among nurses [13]. In addition, there is a lack of conclusive evidence that working in different hospital wards results in diverse rates of compliance with hand hygiene among HCWs. Lebovic et al., suggest that the type of ward is not a predictive [14], Erasmus et al., indicate that compliance is the lowest in ICU [15], while Buffet-Bataillon et al., suggest that compliance with hand hygiene is the highest in intensive care units [5], which correspond with the results of Kowitt et al., which also described higher compliance rates among pediatrics and ICU [12]. According to Wetzker et al., both neonatal ICUs and pediatric non-ICUs maintained higher compliance than adult care units [7]. In contrast, Alsubaie et al., observed the greatest noncompliance rates among pediatric ICU and cardiac ICU [16]. Also, our study demonstrated that there were differences in the effectiveness of the use of hand rub between workers of ICUs and non-ICUs. The use of UV light visualization in the assessment of the accuracy of the performed hand hygiene may also serve as an important part of practical training. In our study the most frequently omitted places were fingertips and nail folds, and the base of the thumb. Similarly these regions were also indicated to be the most frequently omitted by Ariasa et al., and Skodová et al. [10, 17].

Conclusion

The results of our study indicate that the quality and microbiological effectiveness of hand hygiene among Polish HCWs depend on age and experience. The repeated training in hand hygiene with visualization of the omitted parts during the use of hand-rub can be helpful to improve the quality and effectiveness of hand hygiene. The particular attention should be paid to the proper technique of using hand-rub because the technique of hand disinfection was im-perfect - the most often omitted regions during the use of hand rub identified in the UV lamp were fingertips, nail folds, and at the base of the thumb.

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