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ORIGINAL ARTICLE

Could Training Programs Eliminate Hospital Environmental Surfaces Contamination with Multidrug Resistant Bacteria

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ABSTRACT

Background: *Hospital environment could be a risk for transmission of nosocomial infections.* ***Objectives:*** *This study aimed to evaluate the effect of training program on the elimination of microbial contamination of hospital environmental surfaces, devices and health care workers (HCWs) hands.* ***Methodology****: Two phases interventional study was conducted for basal evaluation and training of HCWs and housekeepers on standard precautions with evaluation of environmental surfaces, devices and hands contamination at basal level before as well as after routine cleaning and hand hygiene, also after implantation of a training program.* ***Results****: Significant reduction of environmental surfaces and devices contamination was detected after educational intervention at all departments (p-value >0.001). The most common isolate was S. aureus in operating rooms, orthopedic, and general surgery departments (44.4%, 26.9%, and 22.2% respectively), E.coli was the most common isolate in urology department (21.8%). Bed ledges/ bed arms samples showed the highest contamination level (39%) while curtain edges showed the least contamination site (4.2%). Nurses had the lowest frequency of hand contamination (30%) followed by physicians, the highest hand contamination recorded for housekeepers (50%). E.coli isolated from 47.4% of hands. The most isolated Multidrug Resistant Bacteria was MRSA (54.3%) followed by ESBLs producing E.coli (38.7%). After education there were significant improvements in practice observed for all subjects (p-value< 0.05) and environmental contamination decreased to zero level.* ***Conclusion****: Intervention with a training program has a positive impact on elimination of hospital environment contamination*

INTRODUCTION

Hospital acquired infections (HAIs) are recognized as a worldwide public health problem.[1] It is the most common complication occurred to hospitalized patients and is considered one of the major causes of morbidity and mortality.[2,3] Mortality rate associated with HAIs ranged from 5% to 35%, and may increase to 50% in developing countries.[4] Hospital-acquired infections could be acquired during receiving care within a facility and pose significant risks to patients.[5] A Centers for Disease Control and Prevention reported an estimated 721,000 HAIs occurred in acute care settings in 2011, and about 75,000 mortality during hospitalization.[6] Hospital acquired infections is caused by various types of organisms; viruses, bacteria and fungus. These infections may be caused by agents from endogenous as well as exogenous sources; patient care personnel, equipment, environment, contaminated drugs, or food.[7] Contamination of hospital environment at operating rooms (ORs) and other surgical wards (SWs) is the most hazardous environments in hospitals which may results in development of multi-drug resistant (MDR) strains.[2] Lacking of standardized information and reporting system for HAIs had a negative impact on proper diagnosis and treatment of these types of infections. Identification of cut-off time, carrier status of any hospitalized patient, and determination the burden of disease in community could help in designing an effective infection control strategy in health care facilities.[8] Around 35% of HAIs are preventable, so continues environmental monitoring and active microbiological surveillance of medical devices, hospital environments, and HCWs hands could be considered a fundamental element that identifies potential bacterial pathogens and associated factors with subsequent reduction in incidence rate of HAIs.[9] The present study aimed to evaluate the effect of training program on cleaning, and disinfecting technique on elimination of microbial contamination of hospital environmental surfaces, devices and hands of HCW as well as housekeepers in different departments at Fayoum University Hospitals (FUH).

METHODOLOGY

Study setting:

Fayoum University Hospital is a teaching hospital in the governorate. It has 365 staff members (176 nurse staff, and 189 physicians), and 500 beds. The current study was conducted over a period of 7 months; from June 2018 till December 2018. Cluster random sample was conducted among different hospital departments to select five departments to be included in the study operation rooms (ORs), Surgical Wards (SWs): urology, orthopedic, general surgery, and gynecology departments). As regards health care workers (physicians, nurses) and housekeepers purposive sample was taken from selected departments and no change in HCWs occurred during the period of the study.

Study design:

An interventional study with two phases was conducted:

Phase I: It was a descriptive cross-sectional phase to assess the following:

- Base line evaluation of environment, devices, HCWs and housekeeper hands contamination before and after routine cleaning and hand hygiene by microbiology cultures and aerobic colony count. The main target was frequent hand contact surfaces.
- Assessment of knowledge and practice of the HCWs regarding cleaning and disinfection techniques by using a structured self-administrated questionnaire prepared according to WHO guidelines, formed of two sections: First; demographic data including age, sex, and occupation. Second; 16 questions to assess knowledge of standard precaution.
- Assessment of practice of the HCWs to standard precaution through an observational check list which included (30) items.

The right answer and practices scored as "2" while wrong answer and practices was scored as "zero", with total score of "32" for knowledge and "60" for practice.

Phase II: An interventional training program which conducted for three months to HCWs in selected departments over 12 weeks, and 36 hours; with two hours lecturer and one hour demonstration workshop per week. It included following: the impact of implementation of infection control policies and procedures in reducing infection rates, standardized national infection control guidelines; hand hygiene, personal protective equipment, techniques of environmental cleaning, disinfection and sterilization. At the end of the training courses, the knowledge and the practices of HCWs were reassessed.

Also third time evaluation of the environmental contamination levels was conducted, to evaluate the effect of training program on both improving HCWs knowledge and practice and reduction of microbial contamination in hospital environment, devices, and hands of HCWs and housekeepers.

Microbiological assessment:

A total of 660 samples were collected in the current study in the three times of evaluation; 220 samples in each time: Seventy swabs from ORs surfaces were collected from 9 sites; [operating table top surface (10), anesthesia machine surface (10), instruments trolley (8), electro cautery machine (5), sterilizing hand gel pumps (7), the laryngoscope handles (7), Doors handles (12), diathermy (DC) machine surface (6), and electric power switch (5)]

One hundred twenty three swabs from other SWs surfaces: 42 swabs from urology department ,39 swabs from orthopedics , 26 swabs from general surgery and 16 swabs from gynecology department, these samples were collected from 6 sites: [Doors handles (11), bed side table's surface (28), bed linen (24), bed ledges and arms (31), curtains edges (15), and solutions holders (14)].

Twenty seven samples from HCWs and housekeepers hands by glove juice technique[10]; 9 physicians, 10 nurses, and 8 housekeepers were included in the study.

Environmental and devices samples were performed by aseptic swabbing method as described previously.[11] These swabs were cultured on Nutrient agar, Blood agar and MacConkey agar (Oxoid LTD, Basingstoke, England). Identification of isolated bacteria was done according to standard microbiological methods.[12] Any oxidase-negative Gram negative rods were further identified by Microbact (12A) Gram-negative identification system (Oxoid, Basingstoke, UK). Suspected colonies of *S. aureus* were sub-cultured on Mannitol salt agar, oxacillin resistant screening agar base (Oxoid Ltd, Basingstoke, England) to identify methicillin-resistant *S. aureus* (MRSA) and suspected *Enterococcus* spp. colonies were plated on vancomycin impregnated bile esculin azide agar (Oxoid LTD, Basingstoke, England) to identify Vancomycin resistant *Enterococci* (VRE). The microbial contamination was recorded according to the suggested standards; presence of indicator organisms (*Staphylococcus aureus* including MRSA, *Enterococci*, including VRE and various MDR Gram-negative bacilli) > 1 cfu/cm² and /or a total bacterial count ≥ 5 cfu/cm² indicated high bacterial surface contamination.[11] Below these levels, we considered surfaces are clean. Antimicrobial susceptibility testing of isolated colonies was performed by disc-diffusion method according to Clinical Laboratory Standards Institute (CLSI) guidelines. When the isolated bacteria was resistant to 3 or more antibiotics groups, it is considered a MDR organism.[13] Isolates with one or more of the following were considered extended-spectrum β-lactamase (ESBL) bacteria and were listed for confirmation of ESBL production by the combined disks method: an inhibition zone to cefotaxime ≤ 27 mm, ceftazidime ≤ 22 mm, aztreonam ≤ 27 mm, extension of the zone of inhibition

of any cephalosporins towards amoxicillin/clavulanic acid by the disk diffusion method[14]

Statistical analysis:

Data analyzed using SPSS software (Version 18) under Windows 2010. Categorical data was analyzed by computing percentages, and differences were tested statistically by kruskal wallis test used in comparing more than two independent groups, Wilcoxon tests used in comparing two groups of dependent data, Chi square test to compare two of more than two qualitative groups, Mc-Nemar test for paired dependent qualitative data. The p-value ≤ 0.05 was considered the cut-off value for significance.

Ethical considerations:

This study was approved by Faculty of Medicine Research Ethical Committee and FUH director. The study was conducted after explaining the study aims. Verbal consents were obtained from all subjects included in the study and each person had the right to refuse to participate in the study.

RESULTS

Basal evaluation at phase I of the study before routine cleaning revealed high environmental and devices contamination at all tested departments, with the highest number of contaminated surfaces at urology department (73.8%). Operation room(s) show the least contamination (15.7%) (Table 1). Significant reduction of environment and devices contamination was observed after educational intervention at all departments (*p-value >0.001)* (Table 1). As regarded HCWs, housekeepers hands, basal evaluation showed that nurses had the lowest hand contamination (30%) followed by physicians, the highest hand contamination recorded for housekeepers (50%) (Table 2). No hand contamination was observed for nurses and physicians after hand hygiene and before educational intervention, while the maximum effect for education program was observed for housekeepers as they showed improvement although non-significant (Table 2)**.**

Table 1: Frequency of environmental and devices surfaces contamination at Basal evaluation, after routine cleaning and after training course in different departments

Departments (Number of swabs)	**(Basal evaluation) 1st Swabbing**	**(After routine cleaning) 2nd swabbing**	**(After training) 3rd swabbing**	***p-value***
	No. (%)	**No. (%)**	**No. (%)**	
Operation room (N-70)	11(15.7%)	1(1.4%)	0 (0%)	**0.002*[a]**
Urology (N-42)	31 (73.8%)	11(26.2%)	0 (0%)	**<0.001*[a, b]**
Orthopedic (N-39)	16 (41%)	5(13.5%)	0(0%)	**0.001[*a]** **0.01[*b]**
General surgery (N-26)	14 (53.8%)	4(15.4%)	0(0%)	**0.002[*a]** **0.03[*b]**
Gynecology (N-16)	5(31.3%)	2(12.5%)	0(0%)	0.251
Total	**77(39.9%)**	**23(11.9%)**	**0(0%)**	**> 0.001**
	<0.001[*c]	**0.003[*c]**		

a: statistically significant p-value <0.05 between 1st and 2nd swabbing.
b: statistically significant p-value <0.05 between 2nd and 3rd swabbing.
c: statistically significant p-value <0.05 between different departments

Table 2: Frequency of HCWs and housekeepers hands contamination at Basal evaluation, after routine hand hygiene and after training course

HCWs	**(Basal evaluation) 1st swabbing**	**(After routine hand hygiene) 2nd swabbing**	**(After training) 3rd swabbing**	***p-value***
	No. (%)	**No. (%)**	**No. (%)**	
Physicians (N-9)	4(44.4%)	0(0%)	0(0%)	**0.023[*a]**
Nurses (N-10)	3(30%)	0(0%)	0(0%)	0.062
Housekeepers (N-8)	4(50%)	2(25%)	0(0%)	0.301
Total	**11(40.7%)**	**2(7.4%)**	**0(0%)**	**0.004**
	0.56	0.06		

a:statistically significant p-value <0.05 between 1st and 2nd swabbing.

The current study included 9/27 (33.3%) physicians, 10/27 (37%) nurses, and 8/27 (29.7%) housekeepers with mean age 27.3 ± 3.1 years, 14/27 (51.9%) of them were females and 13/27 (48.1%) were males.

At baseline assessment before intervention with training program physicians had significant high knowledge and practice scores compared to nurses and housekeepers (p-value< 0.05) (Table 3).

Table 3: Comparing knowledge and practice score among HCWs before and after training course.

HCWs	Before training	After training	*p-value* [a]
	Mean ±SD	Mean ±SD	
Knowledge			
Physicians (N-9)	22±2.2	22.4±1.9	0.1
Nurses (N-10)	19.7±2.4	20.2±2.7	0.5
Housekeepers (N-8)	17.5±1.2	24.3±2.4	**<0.001**
p-value [b]	**<0.001**	**<0.001**	
Practice			
Physicians (N-9)	45.8±2.8	50.6±3.1	**0.005**
Nurses (N-10)	37.2±4.4	43.8±3.3	**0.002**
Housekeepers (N-8)	21.8±1.3	34.6±3.3	**<0.001**
p-value [b]	**0.004**	**<0.001**	

a: statistically significant p-value <0.05 between before and after training.
b: statistically significant p-value <0.05 between HCWs.

At the end line assessment, high significant improvements of knowledge, and practice were detected among house keepers (p-value <0.001). But among physician and nurses although there is no significant improvement in knowledge, there are significant improvements in practice were observed for all subjects (p-value< 0.05) (Table 3).

At the basal evaluation phase, the most common isolate was *S. aureus* recovered from ORs, orthopedic, and general surgery departments, 8/18 (44.4%), 7/26 (26.9%), and 6/27 (22.2%) respectively, followed by Coagulase Negative Staph (CONS) 5/18 (27.8%), 4/26 (15.4%), and 6/27 (22.2%) respectively). The most common isolated organism from urology department; was *E.coli* 12/55(21.8%) followed by CONS 9/55 (16.4%), while from gynecological department CONS was 3/10(30%); As regards HCWs hands; *E.coli* represents 9/19 (47.4%) and *S. aureus* represent 7/19(36.8 %) of isolated organisms (Figure 1).

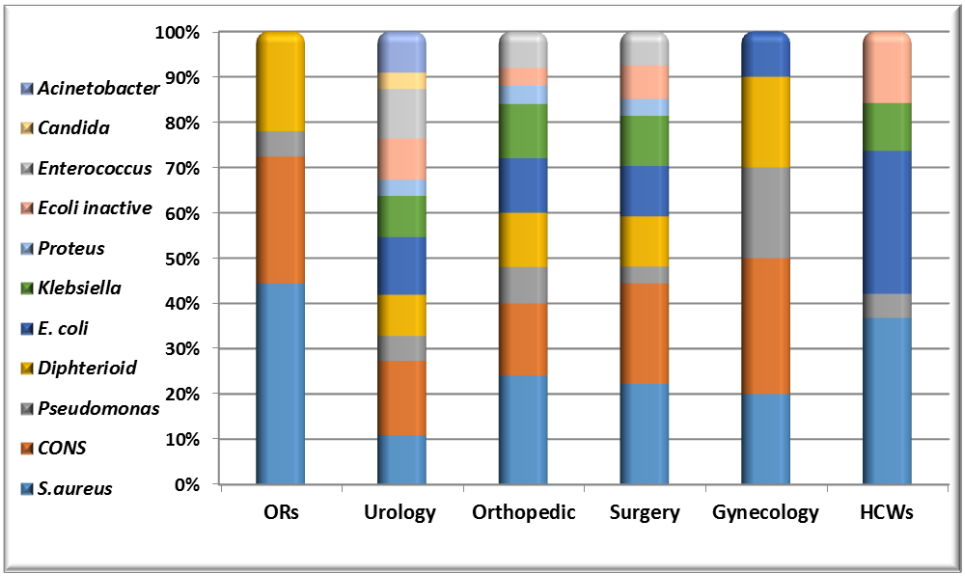

Fig. 1: Frequency of different isolates recovered from different departments

In our study, the most isolated MDR was *S. aureus* (MRSA) which represented 54.3% (19/35**)** of the isolates followed by ESBLs producing *E.coli* which represented 38.7% (12/31) (Table 4).

The SWs swabs; bed ledges/ bed arms samples showed the highest contamination level 46/118 (39%) followed by the bed side tables surfaces 39/118 (33.1%) and the least contamination sites were curtain edges 5/118 (4.2%) (Table 5). In ORs, the highest percentage of isolates were isolated from anesthesia machines surface 5/18 (27.8%), followed by doors handles 4/18(22.2%), no growth was recovered from the sterilizing hand gel pumps or laryngoscopy handles.

Table 4: Distribution of Multidrug resistant bacterial isolates

Isolated organisms	Total number	Total number of MDRs (%)	Distribution of MDRs isolates among groups of the study (%)		
			ORs	Surgical wards	HCWs hands
S. aureus	**35**	**19(54.3%) MRSA**	2 (10.5%)	17 (89.5%)	0 (0%)
E. coli	**31**	**12 (38.7%) ESBL**	0 (0%)	10 (83.3%)	2 (16.7%)
Klebsiella pneumoniae	13	3 (23.1%)	0 (0%)	3 (100 %)	0 (0%)
Pseudomonas aeruginosa.	10	2 (20%)	0 (0%)	1 (50%)	1 (50%)
Enterococcus spp.	10	3 (30 %)	0 (0%)	3 (100%) VRE	0 (0%)
Acinetobacter baumannii	5	1 (20%)	0 (0%)	1 (100%)	0 (0%)

Table 5: Frequency of environmental surfaces contamination in different surgical departments:

Surgical wards environmental swabs	Urology (N=55)	Orthopedic (N=26)	General surgery (N=27)	Gynecology (N=10)	Total N=118 (%)
Doors handles	6	2	2	1	11 (9.3%)
Bed side Table surface	17	9	9	4	39 (33.1%)
Bed linen	2	1	4	1	8 (6.8%)
Bed ledges, arms	19	13	10	4	**46 (39%)**
Curtains edges	5	0	0	0	**5 (4.2%)**
Solution holders	6	1	2	0	9 (7.6%)

DISCUSSION

Hospital environment plays an important role in spread of health care associated infections. Although the main source of nosocomial pathogens is patient's endogenous flora, about 20% to 40% of HAIs have been attributed to cross infection through health care personnel hands, which became contaminated from contact with the patient directly or indirectly by touching contaminated environmental surfaces.[15,16] Basal evaluation in the current study revealed high environmental and devices contamination at all tested departments, with highest contamination at urology department (73.8%) while operation rooms showed the least contamination (15.7%). Although the present result is higher than that reported in Baghdad that found the ORs environmental contamination was 4%[16], it is much less than the contamination reported in ORs in another Palestinian study (51.7 %).[17] The variation in results may be attributed to different approaches in implementation of infection control programs at different countries and even hospitals.

Results of the current study revealed that in surgical inpatient wards the highest levels of contamination were found in bed ledges/ bed arms (39%), and bed side tables' surfaces (33.1%). This differs from another study from Ghana stated that doors handles had the highest number of differential isolates among surfaces.[18] In ORs, anesthesia machines surfaces, doors handles, showed the highest percentage of microbial growth (27.8%, 22.2% respectively). On the other hand, no growths were found in the sterilizing pumps or laryngoscopy handles. These results differ from those reported in a Palestinian study in which 3.33% of contaminated surfaces were instruments table.[17]

Hands of the HCWs are considered one of the major routes of transmission of infection. Consequently, the inanimate hospital environment may be contaminated with different kinds of organisms, especially MDRs, as

MRSA, VRE and MDR gram negative rods.[19] Bingham et al. reported that HCWs acquired at least one pathogen on their hands during 28 % of patient care encounters. Hands sampled before different procedure and hands sampled after body fluid exposure was contaminated in about 17% of instances.[20] Basal evaluation at the present study showed that nurses had the lowest hand contamination (30%) followed by physicians, the highest hand contamination recorded for housekeepers (50%). No hand contamination was observed for nurses and physicians after hand hygiene and before educational intervention, while housekeepers showed improvement although non-significant. Bassyouni et. al[21] reported that nurses significantly had better compliance to standard precautions than that achieved by doctors. Hand contamination in the present study before hand hygiene was less than that of a study conducted in Iran in which the rate of contamination of hands and rings was observed in 73.1% of HCWs.[22]

The present study found that: the most common isolated organism was *S. aureus* from ORs, orthopedic, and surgical department, (44.4%, 23.1% and 22.2% respectively), followed by CONS (27.8%, 15.4% and 22.2% respectively). These results are consistent with results of previous studies conducted in Egypt, Palestine, Austria, Greece and Ethiopia that found the most common microbial contamination in hospitals was *S. aureus*,[17,21-25] Our results are nearly similar to that reported in a study conducted in United Kingdom that found the majority of bacteria cultured from the surfaces of hospital units were CONS and *E.coli*.[26] On the other hand a Poland study stated that CONS was the most numerous isolated bacteria ranged from 77.3% to 95.8% in different hospitals.[19]

Inadequate hand hygiene resulted in a cross-transmission of infection in healthcare facilities.[27] Regarding HCWs hand contamination in our study; *E.coli* represents 47.4% (9/19). This was less than the rate of contamination of hands observed by an American study as 66% of the HCWs were colonized with one or more gram-negative bacilli, and 20% with *S. auras*.[28]

In our study, the most isolated MDR were *S. aureu*s (MRSA) which represented 54.3% **(**19/35) followed by ESBLs producing *E.coli* which represented 38.7% (12/31)**.** These results were lower than the results of a study conducted in Poland which reported that 50% to 57.1% of the analyzed strains of *Staphylococci* showed resistance to methicillin[19] and in Ethiopia, which stated that *S. aureus* showed 100% resistance to methicillin and multidrug resistant Enterobacteriaceae were also seen in more than 90 % of isolates.[25]

Our results reported a significant reduction of environmental surfaces and devices contamination after educational intervention at all departments (*p-value >0.001)* These results come in agreement with other Egyptian studies previously conducted in outpatients clinics and intensive care units and found that there was a significant improvement after health education intervention.[11,21]

Our results stated that physicians had significant high knowledge and practice scores compared to nurses and housekeepers at baseline assessment which also recently reported in Saudi Arabia[29] but contradict with the results of previous studies which stated that nurses have higher compliance rates to standard precautions than other HCWs.[21,30]

The present study detected high significant improvements of knowledge, and practice among housekeepers (p-value <0.001), It seems that the maximum benefits from education program were achieved by housekeepers which also reflected by elimination of environmental contamination at phase II (0% contaminated surfaces). During past years much efforts has been conducted to improve hand hygiene compliance of health care providers. Previous studies had reported the increased incidence of MDR in health care associated infections. [31, 32] And there are much evidence that hospitalized patients who are colonized or infected with antibiotic resistant organisms can shed these organisms into environment, which becomes a reservoir for subsequent transmission.[33] Dancer highlighted on 2014 the association between HAI rates and environmental bioburden.[34] While Alfa et.al. had investigated the role of cleaning compliance in reduction of HAI as when compliance was more than 80%, there was a significant reduction in HAI for MRSA, VRE, and *C difficile*.[33]

Current cleaning protocols may not targeting the correct sites, or may not be applied frequently enough, so ongoing training, education, and continual evidence-based reassessment are required for any infection control program.

CONCLUSION

Training intervention succeeded in elimination of microbial growth in hospital environment and HCWs hands which will have a positive impact on reduction in the incidence of HAIs. Housekeepers should be targeted in implementation of any infection control program.

Conflicts of interest: The authors declare that they have no financial or non-financial conflicts of interest related to the work done in the manuscript.

- Each author listed in the manuscript had seen and approved the submission of this version of the manuscript and takes full responsibility for it.
- This article had not been published anywhere and is not currently under consideration by another journal or a publisher.

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