ORIGINAL ARTICLE

MICROBIAL CARRIAGE OF HOSPITAL UNIFORMS AMONG EMERGENCY MEDICINE RESIDENTS AT THE UNIVERSITY OF THE PHILIPPINES – PHILIPPINE GENERAL HOSPITAL (UP-PGH)

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ABSTRACT

The aim of this research is to identify the microbial flora and pathogen of hospital uniforms (HUs) among emergency medicine (EM) residents at the University of the Philippines – Philippine General Hospital (UP-PGH) and to determine factors affecting their presence. A prospective, cross-sectional design that sampled and cultured bacterial contaminants on hospital uniforms of EM residents at UP-PGH over a 10-day period from 13-23 April 2021 was utilized. Frequency distribution, z-test and chi-square test at p <0.05 statistical significance were used for the data analysis. A total of 22 EM residents, with a mean age of 30 (± 2.77) years participated in the study; more than half were females (54.5%) and went on evening (1900-0700hrs) duty shift (63.6%). Handwashing was done by 45.5% and 77.3% prior to and after seeing a patient respectively. Increases in the proportion of bacterial isolation in the after-duty samples were significantly noted for S. epidermidis at the right pocket (p<0.01), torso (p<0.01), and sleeve (p<0.01). Moderate growth of the bacteria was significantly associated with the morning shift (0700-1900 hours). Hospital uniforms can harbor pathogens and other harmful microorganisms as it is regularly exposed to the hospital environment. Given the growing number of nosocomial infections and increasing bacterial resistance to antibiotics, it is recommended to enforce infection control hospital policies that emphasize the importance of wearing HUs only at the workplace and prohibit its usage in public places. This should include regularly providing freshly laundered HUs, related sterilization services and proper storage.

Keywords: *Microbial carriage, hospital uniforms, emergency medicine residents, UP-PGH*

INTRODUCTION

Healthcare workers (HCWs) are continually exposed to microbes through constant contact with various surfaces and patients, and the patients are, in turn, exposed to the microbes that HCWs carry all throughout the hospital. [1] Part of hospital protocols to minimize contaminations is by wearing pre-approved uniforms. Hospital uniforms (HU), such as scrubs and white coats, are necessary to distinguish hospital personnel from outsiders, display an environment of professionalism, and most importantly, acts as a barrier from outside contamination, which street clothes are exposed to.[2]However, HUs are also progressively contaminated with use and exposure, especially when exposed to non-patient care areas, such as parking areas, canteens, and break rooms, despite daily washing and proper hygiene by personnel.[3] A study by Wiener-Well et. al., demonstrated that up to 60% of uniforms worn by hospital staff, especially those associated with patient care, harbor contaminants such as disease-causing bacteria and viruses, which can be inadvertently transferred to unaware patients, making uniforms a major contributor to nosocomial and healthcare-associated infections.[4]

There are various studies demonstrating HUs exposed to blood and body fluids acting as fomites for both harmless and pathogenic microbes and viruses, and can further be transmitted from patient to uniform and then passing it on to another patient.[4,5,6] It is not only limited to the hospital setting, but also in the pre-hospital setting, such as emergency medical responders in contact with patients on ambulance runs.[4] Aside from workplace exposure, workers may opt to travel to and from work wearing their work uniforms on public or other modes of transportation which exposes it to more surfaces and people.[1]

As a public hospital, the University of the Philippines- Philippine General Hospital (UP-PGH) Emergency Department (ED) receives hundreds of patients daily coming from all over the country. With the construction of a new emergency

department, the current makeshift emergency department is inadequately equipped to handle the number of patients it is currently catering to which can reach up to 200 at one point. When patients are overcrowded and HCWs are placed in non-traditional settings, it can be more difficult to avoid accidental spills and exposures, less accessibility to personal protective equipment, and less compliance to standard infectious control precautions, leading to an increased risk of exposure that can be a major contributor to mortality and morbidity, not only the patients and the wearers, but to other people outside the hospital in contact with it personnel.[3]

These studies not only strengthen the need for personal hygiene among healthcare professionals, but also makes hospital personnel aware that uniforms are potential sources of infection and are therefore a health risk concern.[1,7] With the advent of antibiotic-resistant pathogens, it is not only prudent, but necessary to have clinically effective infection prevention and control practices that ensure patient and staff safety.[8] This pilot study investigated the microbial flora and pathogens found on uniforms of emergency medicine (EM) residents at the UP-PGH and the possible factors affecting their presence. To the authors' knowledge, a study of this nature has not been carried out before at UP-PGH particularly to doctors working in a highly infection-prone area like the ED. It is thus worth exploring and documenting presence of contaminants in their uniforms to prevent and address the problem accordingly based on evidence.

METHODS

The study utilized a prospective, cross-sectional research design, investigating the HUs of EM residents over a 10-day period from 13-23 April 2021. The bacterial isolates comparing the before and after 12-hour duty shift were individually identified by the UP-PGH Medical Research Laboratory (MRL)

Total enumeration of all EM residents who worked at the ED at the time when the study was conducted and those who were able to complete a 12-hour duty shift from 13-23 April, 2021 were recruited and were asked to have their HUs examined. Residents who did not complete their 12-hour due to unforeseen circumstances, those who are not working at the ED for the duration of the study due to outside rotation and those who did not consent to be part of the research were excluded.

Specimen, Data Collection, and Microbial Identification

The study first identified the residents who worked at the ED during the time of the study. A week before data collection, each resident was adequately briefed on the study conduct. Volunteer participants were requested to: 1) submit a personal HU top at least two days prior to the start of the study, 2) take a bath at least two hours before their respective shift, 3) not wear any other piece of clothing, except undergarments, underneath the HU to be worn, 4) not wear their white coats or any clothing on top of the HU. Informed consent was then secured.

All HU tops obtained were subjected to machine washing a day before the actual start of the study using washer water temperatures of 25 ^{o}C, heavy washer cycle, Tide powder detergent with oxygen-activated bleach and high temperature during the drying cycle.

After washing, the uniforms were placed on a clean, unused plastic bag and folded. The HUs were submitted to the Operating Room Sterilization Area (ORSA) for autoclaving with the handlers wrapping each of the uniform in a sealed plastic bag. Aseptic technique was used during the entire process. Autoclaving was done at a temperature of 121 ^{o}C and pressure of 15 PSI for 60 minutes. The HUs were then stored in clean, dry and air-tight container that was placed in an area accessible to the residents.

The sealed uniforms were only opened thirty minutes prior to the duty of the corresponding resident. Before donning, baseline samples were taken from specific parts of the HU. A sterile work area was set up at the call room where sampling was done. Blood agar was particularly used to be able to culture a wide range of organisms as it provides an enriched nutritional environment and also detects hemolytic properties while MacConkey plates grows gram negative and enteric organisms. Specimens were obtained from the torso, sleeve cuffs, and pockets, because these were the areas shown in previous studies of healthcare uniforms to be mostly contaminated,[9,10] as illustrated in Figure1. Samples from the pockets and sleeves were taken from the participant's dominant hand side (right side for right-handed and left side for left-handed) while samples from the torso were taken from the breast pocket side. Contact-plating was the preferred method for sampling as it is known to have higher yields of isolates as compared to swabbing. [11,12] Agar plates were pre-made by the UP-PGH MRL and were placed in a sterile container before pick up for use. The surface sampled were firmly pressed against the agar for three seconds, with the thumb and second finger holding the plate and the first finger of the other hand to press firmly and evenly to the agar.

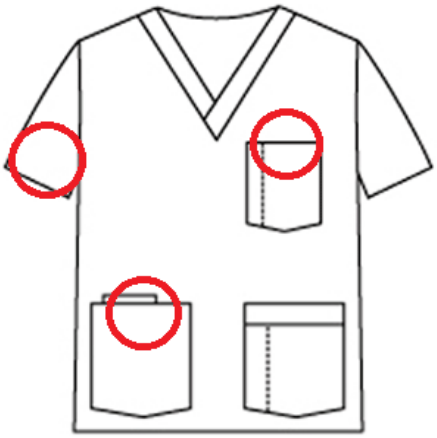

Figure 1. Areas to be plated on the HU

Lateral movement of the plates was avoided to prevent spreading contaminants across the agar surface. Once the entire procedure was done, the plated samples were then placed back inside the sterile containers and stored until transported back to the MRL for culturing. Ideally, once samples were plated, they should immediately be sent for processing within 30 minutes, however the MRL operating hours (weekdays; 0800 to 1700hrs only) precluded strict adherence to this requirement, so the samples from the morning shift were sent the following day as long as they were stored in the sealed, dry containers to prevent contamination. Once baseline cultures were taken, the HUs were given to the residents at the start of their duty, and they were retrieved for sampling again upon completion of the 12-hour tour of duty. Methods of specimen collection, processing and antimicrobial susceptibility testing were based on the quality control procedures specified by the Clinical Laboratory Standards Institute (CLSI).[13]

All plated specimen were submitted immediately to the UP-PGH MRL for culturing and the dilution streak technique for isolation and semi-quantification of bacterial colonies were used. The interpretation of culture plates was done per quadrants- light growth meant the growth was limited to only one quadrant, moderate growth extended to the second, and heavy growth extended to the fourth quadrant.

Each participant was then given a self-administered questionnaire with an assigned code that asked general information about the participant, details about their duty when the study was done and their patients handled, and handwashing habits.

The qualitative data gathered from the study was analyzed using descriptive statistics; thru determination of mean, standard deviation, range, frequency and percentage. A series of z-test of proportions were carried out to determine differences in the positive and negative bacterial cultures before and after putting on the uniform and chi-square tests to determine the differences in the bacterial load across select characteristics of the study population. The level of significance was set at a p-value less than 0.05 using two-tailed comparisons at 95% CI. Ethics clearance was secured from UP-Manila Research Ethics Board (UPM-REB 2020-419-01) before the implementation of the study.

Operational Definition of Terms

Hospital Uniform – standard green and black, cotton scrub suit for the EM resident's use during their tour of duty

Emergency Medicine Residents – physicians who are currently undergoing training in EM at UP-PGH for the year 2021

Microbial Carriage – refers to the presence of a microbe for a short period of time on a surface or object from the environment, or from patients who are colonized or infected.[1]

Bacterial Load – the number of colony-forming units identified during culture, which will be defined semi-quantitatively as light, moderate, and heavy following standards set by the UP-PGH MRL

UP-PGH MRL – a laboratory unit in PGH that is only open during weekdays 8AM-5PM, it processes samples for culturing from research conducted at UP-PGH

Emergency Severity Index (ESI) – refers to the triage acuity classification at the ED. ESI 1 needs urgent medical attention and could die within 15 minutes if no interventions are given or is already dead-on arrival. ESI 2 patients are unstable patients but can tolerate a longer waiting time, but they are still high-risk patients, and need to be seen within the hour. ESI 3 patients are stable patients who still need to be seen by a physician but can tolerate a waiting time of more than an hour. They are less likely to deteriorate within the day.

Emergency Room Officer (ERO*)* – a 3rd EM resident who is in-charge of overseeing the daily ED operations and clinically supervising the junior residents.

Triage Officer – a 2nd or 1st year EM resident who are the first line doctors receiving patients at the triage area and is in-charge of decking patients based on their ESI. They see more patients since they are the ones receiving all the patients, however contact time per patient is less as they are not required to do a full physical examination

Treatment Officer (TO*)* – a 2nd or 1st year EM resident who is in-charge of managing patients inside the resuscitation area decked as ESI 1, 2, or 3; they have more contact time per patient and perform thorough physical examination

Outside Rotation – an EM resident currently undergoing training in other services inside the hospital eg. Pediatrics, Otorhinolaryngology, Ophthalmology, Orthopedics, and Trauma. They may not be physically present at the ED, as they are posted to their respective specialty department

RESULTS

All 22 EM residents who were posted at the ED during the implementation of the study were included, the mean age was 30 (± 2.77) years, the oldest being 37 years of age and the youngest was 24. Majority were female (54.55%) and went on evening shift (1900-0700 hours). Twelve residents (54.5%) had 6 patients or less, and most treated patients with infectious disease (90.9%). For duty assignments, 18.2% were working as EROs, 4.6% was on outside rotation (Pediatric ED), 54.5% were TOs while 22.7% were triage officers.

Only 45.5% (10/22) stated that they hand washed prior to seeing a patient while most (77.3%) washed their hands after providing patient care. Reasons for not handwashing were due to workload (31.8%) and inadequate resources (4.6%) or both (22.7%). More than half (54.5%) preferred an alcohol-based handwashing method, followed by antimicrobial soap (27.3%) with water, while only 13.6% preferred more than 1 method of handwashing (Table 1).

Results showed that there was an increase in the proportion of bacterial isolation in the after-duty samples as detailed in Table 2 below. This can be noted for the right pocket ($p<0.01$), torso ($p<0.01$), and sleeve ($p<0.01$). The isolated organism showing significant growth was *S.epidirmidis* from the dominant hand pocket (81.82%), from the torso (72.73%), and from the sleeve (68.18%). Other isolated species were *Staphylococcus sp.* torso, (22.73%) and sleeve, (9.09%); *K. pneumonia* - dominant hand pocket, (4.55%) and sleeve, (4.55%); and Group D Non-Enterococcal *Streptococcus*- torso, (4.55%).

Majority of the participants in the study handled more than three patients (90.91%) which ranged between 3 to 46. There was no association between bacterial load and most of the socio-demographic characteristics (Table 3) and there was a significantly higher proportion of moderate growth among those from the morning shift (0700-1900 hours) than those from the evening shift ($p=0.02$).

Table 1A: EM Resident's demographics, duty assignment and handwashing practices

Characteristics	No. of Residents	
Age in years	n	%
24-27 years	2	(9.1%)
28-30 years	12	(54.5%)
31-37 years	8	(36.4%)
Sex		
Female	12	(54.5%)
Male	10	(45.5%)
Number of Patients Seen/shift		
≤ 6 patients	12	(54.5%)
> 6 patients	10	(45.5%)
Type of Patients Seen		
Non-infectious	2	(9.1%)
Infectious	20	(90.9%)

Table 1B: EM Resident's demographics, duty assignment and handwashing practices

Characteristics	No. of Residents	
Visited Areas Outside ED		
No	12	(54.5%)
Yes	10	(45.5%)
Duty Assignment		
ERO*	4	(18.2%)
Outside Rotation	1	(4.6%)
Treatment Officer	12	(54.5%)
Triage	5	(22.7%)
Duty Time(hrs.)		
0700-1900 (morning)	8	(36.4%)
1900-0700 (evening)	14	(63.6%)
Hand washes before seeing Patient		
No	12	(54.5%)
Yes	10	(45.5%)
Hand washes after seeing patient		
No	5	(22.7%)
Yes	17	(77.3%)
Preferred Handwashing Method		
Plain soap with water	1	(4.6%)
Alcohol-based / Waterless	12	(54.5%)
Antimicrobial soap with water	6	(27.3%)
More than 1 of above methods	3	(13.6%)
Reasons for not handwashing		
Workload	7	(31.8%)
Resources	1	(4.6%)
Workload, Resources	5	(22.7%)
No reason	9	(40.9%)

Table 2. Microorganisms found in Uniforms across Timing

Organism	Before Duty	After Duty	p-value 95% CI
Dominant Hand Pocket			
No growth	21 (95.45%)	4 (18.18%)	**<0.01***
S. epidermidis	1 (4.55%)	18 (81.82%)	
K. pneumoniae	-	1 (4.55%)	
Torso			
No growth	21 (95.45%)	2 (9.09%)	
Staphylococcus sp.	1 (4.55%)	5 (22.73%)	**<0.01***
S.epidermidis	-	16 (72.73%)	
Group D Non-Enterococcal Streptococcus	-	1 (4.55%)	
Sleeve			
No growth	22 (100%)	5 (22.73%)	
Staphylococcus sp.	-	2 (9.09%)	**<0.01***
S.epidermidis	-	15 (68.18%)	
K. pneumoniae	-	1 (4.55%)	

***** *-significant p value*

Table 3: Bacterial Load across Select Characteristics

Characteristics	No Growth	Light Growth (%)	Moderate Growth (%)	p-value 95% CI
1. Frequency (%)	1 (4.55%)	10 (45.45%)	11 (50%)	-
2. Age in years				
24-27 years	-	1 (10%)	1 (9.09%)	0.84
28-30 years	1 (100%)	6 (60%)	5 (45.45%)	
31-37 years	-	3 (30%)	5 (45.45%)	
3. Sex				
Female	1 (100%)	5 (50%)	6 (54.55%)	0.63
Male	-	5 (50%)	5 (45.45%)	
4. Type of Patients				
Non-infectious	-	2 (20%)	1 (9.09%)	0.64
Infectious	1 (100%)	8 (80%)	10 (90.91%)	
5. Number of Infectious Patients				
≤ 6 patients	-	6 (60%)	6 (54.55%)	0.52
> 6 patients	1 (100%)	4 (40%)	5 (45.45%)	
6. Number of Non-Infectious Patients				
≤ 6 patients	1 (100%)	8 (80%)	9 (81.82%)	0.27
> 6 patients	-	2 (20%)	2 (18.18%)	
7. Visited Areas Outside ED for >5 minutes				0.71
No	-	2 (20%)	1 (9.09%)	
Yes	1 (100%)	8 (80%)	10 (90.91%)	
8. Duty Assignment				
ERO	-	3 (30%)	1 (9.09%)	
Outside Rotation	-	-	1 (9.09%)	0.33
Treatment Officer	-	6 (60%)	6 (54.55%)	
Triage	1 (100%)	1 (10%)	3 (27.27%)	
9. Duty Time				
0700-1900 hours (morning)	-	1 (10%)	7 (63.64%)	**0.02***
1900-0700 hours(evening)	1 (100%)	9 (90%)	4 (36.36%)	
10. Hand washes Before seeing patient				
No	1 (100%)	6 (60%)	5 (45.45%)	0.52
Yes	-	4 (40%)	6 (54.55%)	
11. Hand washes After seeing patient				
No	-	3 (30%)	2 (18.18%)	0.72
Yes	1 (100%)	7 (70%)	9 (81.82%)	

***** *-significant p value*

DISCUSSION

Worldwide, antibiotic-resistant bacteria and opportunistic infections are increasingly persistent and worrisome. It contributes to the rising healthcare costs by lengthening hospital stay and causing morbidity and mortality in infected patients.[14,15] Patients are not the only ones affected by nosocomial hospital transmission of pathogens as there have been studies to suggest that healthcare workers (HCWs) can be contaminated through patient exposure and contact, and they, in turn, transmit it to other patients, their families, and everyone else they come in close contact with. Transmission can be through direct contact with the body, or through fomites, such as clothes and medical equipment used.[4]

Hospitals usually place a lot of emphasis in maintaining a clean environment and implement certain set rules and regulations on how to maintain it. Most studies focus on finding reliable ways to decontaminate surfaces, with emphasis on hard surfaces such as floors, tables, and door handles. There is considerably less effort in decontaminating soft surfaces or textiles such as curtains, furnishings, and HUs.[1] Otter et. al. reported that patients shed enough microorganisms to permeate hospital surfaces and can survive for extended periods that is sufficiently long enough to facilitate transmission to whomever comes in contact with the surface despite attempts of adequate disinfection.[16] There are reports that unclean surfaces contribute to transmissions of *Clostridium dificile*, Vancomycin-resistant Enterococci (VRE), Methicillin-resistant *S.* aureus (MRSA), *Acinetobacter baumanii*, *Pseudomonas aeruginosa*, and Norovirus and up to 92% of hospital privacy curtains can be contaminated in one week by such

bacteria which can lead to epidemic and endemic outbreaks.[17]

Textiles have a complex role in propagating pathogen and infectious organisms. Clothing, such as hospital uniforms (HUs) and scrubs can act as the vector of transmission.[7] Most HCWs wear their HUs throughout their duty which would last for 24 hours or more, with no time to change due to the demands of clinical load. Most hospitals typically do not have any guidelines on how to care for HUs, as to when to change, and where it is allowed to be worn.[18] There is rarely a system where the health facility is responsible for laundering HUs of staff, and even if there is a system in place, post-laundry handling practices are poor that the HUs are prone to contamination. The washing process typically removes these organisms from clothing; however, it may also be a source of recontamination if not done properly.[19,20]

This study removed any confounding factors with regards to the contamination of the uniform before the duty shift. The uniforms were, washed and sterilized following strict aseptic technique and the wearers were required to take a bath at least an hour before the shift. These were necessary steps as there are some studies that were able to culture normal skin flora from freshly laundered and unworn HUs.[21] The effectivity of the sterilization process was shown in this investigation as there were only significant growth between cultures in 2 out of 66 samples from pre-worn HUs while 57 samples from worn HUs had bacterial isolates. The plastic seal of the two pre-worn uniforms may have been breached during the process, explaining the growths.

The demographics of the study participants showed no significant correlation between samples, the same with handwashing habits, number and type of patients, and designation position. The findings of West, et. al. with twice the sample size of this study suggested that factors other than age, sex, experience, and education were the determinants of microorganism growth.[22] Major sources of transmission are through direct contact with the patient, bodily fluid secretions, or touching contaminated surfaces. [23] Hand contamination is the most significant mode of transmission,[24] and infection control measures recommended by the Centers for Disease Control and Prevention (CDC) include proper hand hygiene, handwashing with soap and running water, using of alcohol and changing gloves for every patient contact. During the pandemic, stricter rules on personal protective equipment (PPE) were implemented; gloves and alcohol were more available, and limited patient contact time were enforced. Patients who are considered infectious, those on mechanical ventilators and requiring aerosolizing procedures were placed in rooms with high efficiency particulate air (HEPA) filters to curb spread of disease. Specific areas for donning and doffing of PPEs were also set up to avoid cross-contamination. Exposure of ED personnel and patient were also limited by restricting entry of patient watchers and other hospital staff without valid transaction at the ED. A noticeable decrease in interactions within the ED can also be attributed to having the triage area moved to outside of the ED gates. Minor procedures that did not need any specialized equipment were done at the outdoor tent.

For the most part, PPEs worn served as a sufficient barrier and effective safeguard in addition to regular handwashing. But despite proper hand hygiene and appropriate gloving, contaminants can already be present in HUs prior to patient contact, either from the environment or the HCW themselves. The HCW can be probable carriers of infectious pathogens. The current study showed that most factors relating to the EM resident's profile, duty assignment and handwashing practices were found to be not significantly correlated with bacterial isolation, albeit there was a significant proportion of moderate growth during the morning shift compared to the night shift. This could be attributed to a higher overall patient volume during the day. The ED generally receives more patients and more foot traffic during the day, and this can lead to potentially greater contamination. [16,17,18,25] During the latter part of the day, non-urgent patients avoid consulting at the ED and would usually decide to come the following day when more convenient circumstances permit. The research was conducted during a period of restricted mobility with curfew, making it difficult for people to come to the ED at nighttime accounting for the noted difference. With relatively lesser patients, there is lower chance of committing errors that would lead to the contamination. [22] During the study period, the ED had received around 2,500 patients for the month of April with the 4-man duty team attending to 9-10 patients per 12-hour duty shift. Due to the minimal resources and limited manpower at the ED of a public tertiary referral center such as PGH, most of these new patients were single handedly managed by the EM resident as other available medical staff were preoccupied with various healthcare tasks. Morgan, et. al. reported that 20.5% of HCW interactions with patients resulted to contamination, often by multidrug resistant organisms (MDROs) even during routine and basic patient care. Risk factors include positive environmental cultures, duration of stay in room is >5min, performance of physical examinations and contact with the respiratory ventilator.[26]

The results of the current study showed that *S. epidirmidis* was the most commonly grown microbe on both the pre-worn and post-worn samples HUs. This can be attributed to the fact that S. *epidirmidis* is the most abundant bacteria on healthy human skin which is in constant contact with the uniform surface.[27,28,29] However, no significant correlation between the different HU sites was noted, namely: the dominant hand pocket, breast pocket and sleeves. The sterile gown placed over the HU could have played a significant barrier as they cover almost the entire body from the neck down to the knees. The same can be surmised as to the role of the sterile gloves worn by the EM residents.

A hospital uniform is essentially a surface that moves throughout the hospital facility and can come in direct or indirect contact with other hospital personnel, patients and the general public. At the end of a work shift, HUs can collect different microbes and provide them a moisture and protein-rich environment to thrive and proliferate.[25] In a study by Weiner-Well et. al. which took specimen from sleeves, waists and pockets of HUs of over 100 physicians and nurses, healthcare-associated pathogens were isolated from 63% of the samples, 60% of which were multi-drug resistance organisms.[30] However, other microorganisms were identified as normal human skin flora, as expectedly so, due to constant and prolonged skin contact. Commonly occurring bacteria were *S. aureus* and *Enterococcus* which pose little to no risk as they do not cause serious infection in humans. The potentially dangerous species in the clinical setting include *Bacillus cereus, Acinetobacter spp.* and *Aspergillus flavis*. Other sources of contamination would be from the environment such as surfaces that clothing come into contact with.[4,7] Other bacteria that were isolated from the 12-hour post-duty samples were *K. pneumonia*, *S. aureus spp*, *Bacillus spp,* and Group D Non-Enterococcal *Streptococcus* which are known to be associated with hospital-acquired infections. These can cause complications such as bacteremia, pneumonia, urinary tract, skin, and soft tissue infections[23] particularly in the ICU, a setting that is comparable to PGH-ED that generally functions as an intensive acute care area as infectious patients on mechanical ventilators and requiring various invasive procedures are staying for prolonged number of days. With the provisions taken to make sure the uniforms were uncontaminated prior to being worn, the results clearly showed the potential for uniforms to be a reservoir for pathogens and can contribute to the spread of nosocomial infection.[28]

Several limitations were identified in the conduct of the study. The small number of participants (n=22) from only a single clinical department (EM) may not be enough to fully determine extent of HU contamination. The sole inclusion of residents and not recruiting other types of health workers eg. nurses, utility workers, phlebotomists, etc. with significant exposure to the ED environment may only represent the working practices of a specific group of physicians. Caution is thus advised in the generalizability of results to other healthcare workers posted at the ED or the other areas of the hospital. The year-round pattern of bacterial burden, which is a potential modifier and confounder, was not part of the evaluation but is strongly recommended to be considered in future investigations of similar nature. Lastly, the unexpected occurrence of a pandemic during data collection may have skewed the result to underestimation of the actual microbial carriage of HUs as strict compliance to infection control measures have greatly affected EM resident's practices and work environment.

RECOMMENDATIONS

Although it was not determined how long these organisms can last on textile, it is still possible for pathogens to survive during the resident's 12-hour duty shift as contact with patients having hospital-acquired infections typically first appear within the first 48 hours of admission. The need for protocol regarding uniform washing and donning in hospitals is highly advocated.[23] Other precautions may be put into place, such as wearing of PPE over freshly laundered uniforms and underscoring hand sanitation, with the means and facilities to carry it out being ensured. [31] For future studies on hospital uniform contamination, it is recommended that a third set of samples should also be taken 48 hours after the duty shift to ascertain if the pathogens that may latch on during the duty shift of the resident can survive for prolonged periods of time. This can form part of the evidence that wearing of the uniforms outside of the work premises might actually pose a risk to the general public. A more in depth look on where the contamination could have come from could be done from taking environmental cultures and from the patients personally handled by the participants. A more quantitative count of bacterial growth is also preferred with the possible inclusion of viral and fungal cultures.

An attempt to compare multiple sites on a uniform, especially between the dominant hand and non-dominant hand pockets can also be done. Disposable uniforms can also be used and can be infused with various anti-septic agents to find out what is effective in keeping microorganisms off hospital uniforms.

CONCLUSION

The crowded conditions, high patient volumes, severe patient acuity and suboptimal conditions at the EDs relegated hand hygiene to be least of the priorities. This was even made more difficult with critical patients seen at this area leading to higher chances of exposure to body-fluids which a perfect setting for contamination.

This study has shown that among the after duty HUs worn by EM residents, there was a significant growth of pathogens such S. *epidermidis, Staphyococcus sp.,* Group D Non-Enteroccoccal *Streptoccoccus*, and *K. pneumoniae*. Those going on morning shift (0700-1900 hours) also had significant association with moderate growth of microorganisms.

The risk of transmission and cross-contamination of hospital bugs can potentially be prevented by requiring HCWs to wear freshly laundered dedicated HUs during their tour of duty and restricting wearing of uniforms outside the workplace. Infection control policies must be instituted which would provide regular supply of HUs before duty shift, free sterilization services and proper storage. Institutionalization of such policies may need analysis that will weigh the benefit of infection control vis-à-vis the cost of providing HUs.

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CONFLICT OF INTEREST DISCLOSURE

The authors have no conflict of interest to declare.

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