Predictors of Growth of *Escherichia Coli* on Lab Coats as Part of Hospital-Acquired Infection Transmission Through Healthcare Personnel Attire

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Abstract

Background: Healthcare personnel (HCP) attire could be potential vehicles for microbial transmission. This study aimed to explore the extent of bacterial contamination and hygiene and handling practices of healthcare personnel attire that could influence bacterial growth.

Methods: Descriptive, cross-sectional study was used in this study. Convenience sampling of the 188 healthcare personnel was recruited from a main holistic hospital in the northern part of Jordan. Three swab samples were collected from three different parts of lab coats used by each participant. ANOVA test and the generalized mixed linear model were used for the categorical variables of three or more levels and identify the predictors of positive growth of *Escherichia coli* on healthcare personnel attire.

Results: *Enterococcus faecalis* was the most common species of bacteria found on lab coat. Despite of no statistically significant differences were found, the HCP attire coming from the critical care units and the emergency department were highlighted with slightly higher contamination compared to other departments. *Escherichia coli* 's near-significant growth differences ($p=0.057$) were found based on different locations on lab coats compared to other types of bacteria. Factors associated with significant growth of *Escherichia coli* on healthcare personnel attire were age ≥ 36 years, a high income, bachelor marital status, working as a physician, lab coat use preferred over scrubs, and borrowing of lab coats.

Conclusion: Healthcare personnel should be cautious about the method of use and storage of lab coats they wear.

Background

Healthcare-associated infection, also known as nosocomial infection, is a major challenge in healthcare systems particularly in intensive care units and for patients and families visiting hospitals.¹ Intensive care units have immunocompromised patients who are at higher risk of getting infected with opportunistic pathogens present in hospitals.² The World Health Organization (WHO) defines healthcare-associated infection as the infection that usually becomes evident after 48 h of patient admission to a hospital; the infection is not present at the time of the admission or immediately after discharge.³ Healthcare-associated infection cause increased morbidity, mortality, and healthcare burden.^{4,5} It is estimated that 7 and 10% of hospitalized patients in developed and developing countries, respectively, will acquire at least one healthcare-associated infection at any given time.⁶

Clinical settings, mainly hospitals, are environments where patients are at high risk of getting infections from healthcare personnel. Of these settings, intensive care units are highly susceptible to nosocomial pathogens due to poor sanitation,^{7,8} invasive monitoring procedures, and immunocompromised patients.⁹ Therefore, intensive care units should be sterile and free of microorganisms as much as possible; those transported by healthcare personnel predisposes patients to healthcare-associated infection.

Recent evidence indicate that healthcare personnel's hands are the main vehicle and source of cross-contamination to patients.^{5,10} However, the transmission of microbes from healthcare personnel and clinical devices to patients has also been reported.^{11,12} These infections could be transmitted to hospitalized patients through textiles, such as lab coats, and mobile and medical devices used by healthcare personnel. Evidence supporting this hypothesis has never been reported in Jordan.

White coats have a long traditional history of being a symbol of hope, healing, and identification for medical professionals. However, there has been a concern that white coats may play a potential role in the transmission of pathogenic microorganisms within and outside hospital settings.^{13,14} The material used in lab coats plays a salient role in microbial adhesion, in which fabric blended with cotton is more likely to catch microbes more than fabric made completely from polyester.¹⁵ Healthcare personnel, such as nurses and doctors, who wear white coats over their uniforms are at a higher risk for transmitting microbes through lab coats to their patients.

After admission to a hospital, a condition known as dysbiosis, which is the loss of "health-promoting" bacteria in human body, makes the body vulnerable to any pathogens in the hospital environment, especially to nosocomial infections.¹⁶ The most common among dangerous bacteria that are transmitted and cause severe illnesses and deaths in hospitalized patients, are clustered in what is known as the ESKAPE group (*Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter* species). The hazard of this group is due to their multidrug resistance.¹⁷ The species in the ESKAPE group that were found to be transmitted through lab coats include a methicillin-resistant *Staphylococcus* spp., *Pseudomonas* spp., *Klebsiella* spp., *Escherichia coli* (*E. coli*), and vancomycin-resistant *Enterococci* spp.¹⁵

The prolonged use of a lab coat and the greater number of coats used by a healthcare personnel are associated with higher number of isolates on the sleeve of the coat compared to other parts.¹⁸ The white coat used by Jordanian healthcare personnel has long sleeves and two pockets at waist level, reaches the mid-thigh, and is made from a blend of polyester and cotton fabrics.

The hand hygiene of healthcare personnel plays an important role in microbial transmission. Touching items during or after the physical examination of patients without hand washing can act as a vehicle for the transmission of healthcare-associated infection to patients and objects.¹⁹ Therefore, the aim of this study was to identify, describe, and explore the extent of bacterial contamination and the species of bacteria, particularly *Escherichia coli* (*E. coli*), on healthcare personnel attire. It also aimed to identify the hand hygiene practices of healthcare personnel that might reduce and control bacterial growth.

Methods

Design and setting

A descriptive, cross-sectional design was used in the current study. Cross-sectional study is useful to assess and describe the health status of communities²⁰ in a relatively short period during data collection and less cost. Convenience sampling of 188 healthcare personnel, including physicians, nurses, and allied health (medicine, nursing and pharmacy) students, was used in our study. The current study was conducted in one of the main hospitals located in the northern part of Jordan.

Data and Sample Collection

Approval (Rf#20180170) from Jordan University of Science and Technology (JUST) was obtained to conduct this study. Each participant completed an anonymous, self-administered, and structured research questionnaire (socio-demographic data). Three swab samples were collected from three different locations (collar, mid-sleeve, and waist) on the lab coat or scrub used by the participants. Three milliliters of phosphate buffered saline was added to sterile cotton swabs before sample collection. An area of 10 by 10 cm of each three locations of the lab coat or scrub was swabbed. Then, the swabs were examined.

Total Plate Count and Sample Storage

Each swab sample was vortexed in a solution for 10 sec to release the bacteria into the solution. Serial dilution was performed and 100 µl from two dilutions were inoculated onto two nutrient agar plates to estimate the colony forming units for each sample. Colonies were counted after overnight incubation at 37°C. For stock keeping, 5 ml Tryptone soya broth (Oxoid, UK: CM0129) was added to each swab and incubated at 37°C for 48 h, followed by mixing 1 ml of the culture with 666 µl of 50% glycerol and storage at -80°C. Colonies were cultured on four different differential media to identify major bacterial pathogens as follows: *Staphylococcus aureus* was grown on Baird-Parker agar; *Klebsiella pneumoniae* and *Escherichia coli* were grown on MacConkey agar; *Pseudomonas aeruginosa* was grown on cetrimide agar; and *Enterococcus faecalis* was grown on bile esculin agar.

Statistical Analysis

The mean and standard deviation were used to describe continuous variables, whereas the frequencies and percentages were used for categorical variables. The multiple response analysis was used to describe the prevalence of the grown species across the three different lab coat locations (collar, mid-sleeve and waist), accounting for the dependency between those measured bacterial species. Cochran's Q chi-squared test was used to assess the correlation between the growth of specific bacterial species across the locations, assuming that the three locations were repeated-measures for the same participant. The factor analysis for categorical variables was used to assess age, marital state, monthly income, number of family members that the healthcare personnel live with, and specialization. ANOVA test was used for the categorical variables of three or more levels. The generalized mixed linear model was used to identify the predictors of bacterial growth on healthcare personnel attire.

Results

One hundred eighty-eight healthcare personnel and allied health students participated in the current study. The mean age of the participants was 28.10 (SD = 5.67) y, ranging from 19 to 43 y old. The distribution of the age groups of healthcare personnel was as follows: 52.7% were aged between 19 and 27 y; 37.2%, between 28 and 35 y, and 10.1%, between 36 and 43 y. More than half of the participants were women (57.4%). In addition, about 53.2% of the participants were never married. Of the participants, allied health students accounted for 31.4%; nurses, 36.7%; and physicians, 31.9%. The department-wise distribution of participants was as follows: surgical floors, 21.8%; medical floors, 33.5%; critical care units, 17.6%; outpatient clinics and auxiliary departments, 12.8%; and emergency department, 14.4% (Table 1).

With respect to clinical experience, 29.8% of participants had less than 1 y experience; 29.8%, between 2 and 5 y; and 40.4%, >5 y. As for economic status, 31.4% of the participants had household monthly income of less than 400 JOD. The mean household size or number of family members was 4.15 (SD = 2.3) members. Majority of the participants lived with their spouses and children (28.7%).

Table 2 displays the handling behaviors and the hygiene and washing practices of uniforms or lab coats used by the healthcare personnel. Around half (50.5%) of the personnel preferred to wear white lab coats over scrubs for their daily work. The average number of uniforms or lab coats owned by the healthcare personnel was 2.1 (SD = 0.82). The mean number of washing times of healthcare personnel attire per month was 7.42 (SD = 6.86). Most of the participants (55.3%) washed their uniforms between 1 and 4 times per month and 41.5% of the participants washed their uniforms or lab coats once every three days. Of the participants, 29.8% owned only one uniform or lab coat. The majority of the participants (53.2%) kept their uniforms or lab coats inside hospital lockers, whereas 46.8% kept theirs at home.

Around half (54.3%) of the participants owned the same uniform or lab coat for less than 1 y, while 45.7% owned theirs for more than 1 y. Only 13.3% of the healthcare personnel borrowed their uniforms or lab coats from their work peers; 36.7% were assigned or had contact to ten patients or fewer every day; 27.7% had contact to 10 to 15 patients every day; and most of the participants (35.6%) had contact to or cared for more than 15 patients every day. The majority (83%) mentioned that they wear uniforms or lab coats to comply with professional attire or dress code. In addition, 96.3% of the participants agreed that uniforms and white lab coats can be potential vehicles of pathogens to their patients (Table. 2).

Table 3 displays the bacterial growth findings yielded from screening healthcare personnel attire using surveillance swabs of three locations of each attire. Regardless of the location, presumptive growth types of bacteria were as follows: 77.7% of the healthcare personnel attire had *E. faecalis*; 31.2%, *S. aureus*; 28%, *E. coli*; and 5.1%, *P. aeruginosa*. The mean of number of colony forming units in the inoculated petri dishes was 9.81 (SD = 4.46). Pertaining to certain locations on healthcare personnel attire, the distribution of positive bacterial growth was as follows: the collar had mean colony forming units 3.22 (SD = 1.69), mid-sleeve had 3.32 colony forming units (SD = 1.879), and waist had 3.27 colony forming units (SD = 1.88) (Figure 1).

The proportions of the species of bacteria across three different locations of healthcare personnel attire were compared using the Cochran's Q chi-squared test for significant differences. The analysis findings

showed that none of the four species (*Enterococcus faecalis* ($p = 0.224$), *Staphylococcus aureus* ($p = 0.711$), *Escherichia coli* ($p = 0.057$) and *Pseudomonas aeruginosa* ($p = 0.197$)) differed significantly between the collar, mid-sleeve, and waist (Table 4).

Moreover, the one-way ANOVA revealed no statistically significant mean differences in the number of recovered organism CFU across healthcare workers from various hospital units ($p=0.080$). However, the HCP attire from critical care units and emergency rooms showed a slightly higher mean recovered CFU (Figure 2).

The generalized mixed linear model (Table 5) showed that the attire of healthcare personnel aged between 28 and 35 y exhibited significantly lower mean colony forming units compared to those of personnel aged ≥ 36 y ($p = 0.021$). The same model revealed that attire worn by male healthcare personnel exhibited significantly lower mean colony forming units compared to those worn by female personnel, accounting for other predictors in the analysis ($\beta = -0.112$, $p = 0.007$). The participants with household monthly income less than 400 JOD exhibited significantly lower mean colony forming units compared to those with monthly income more than 800 JOD ($p = 0.011$), accounting for the other predictors. Allied health students' attire exhibited significantly lower mean colony forming units compared to physicians ($p < 0.001$). The attire of healthcare personnel who work in critical care units, showed significantly higher mean colony forming units than the attire of those who work in the emergency department ($\beta = 0.283$, $p < 0.001$), accounting for other predictors in the model.

The same analysis model revealed that healthcare personnel who live alone measured significantly higher mean attire colony forming units compared to those who live in shared residence ($\beta = 0.225$, $p < 0.001$). healthcare personnel living with spouse, children, and parents showed significantly greater mean attire colony forming units compared to those living with friends/others ($\beta = 0.119$, $p = 0.020$). The healthcare personnel who used white coats exhibited significantly lower mean attire colony forming units compared to Scrubs ($\beta = -0.124$, $p = 0.014$). The attire of healthcare personnel who owned only one uniform had significantly lower mean attire colony forming units compared to those of personnel who owned three uniforms ($\beta = -0.174$, $p < 0.001$).

In addition, the analysis model showed that the personnel who did not borrow their uniforms from their peers exhibited slightly lower mean attire colony forming units compared to those who borrowed their uniforms from other work peer ($\beta = -0.092$, $p = 0.068$). The attire of personnel who prefer to carry their uniforms covered by anything other than bag had significantly higher mean attire colony forming units than those of personnel who carry their uniforms by hand without cover ($\beta = 0.121$, $p = 0.006$). Moreover, the attire of personnel who carried their uniforms in a bag exhibited significantly lower mean attire colony forming units compared to those of personnel who carried their uniforms by hand and without cover or bag ($\beta = -0.100$, $p = 0.022$).

Because of the nearly significant growth differences of *Escherichiacoli* ($p=0.057$) at different locations on lab coats from other types of bacteria (Table 4), we performed a bivariate analysis for the occurrence of

Escherichiacoli in association with the HCPs' sociodemographic, professional, and attire hygiene practice levels (Table 6).

In the chi-square test, positive *E.coli* growth on HCP attire was associated with the female sex ($p=0.032$; Table 6) and old age (mean: 29.10 ± 4.35 vs. 27.92 ± 5.82 years; $p=0.046$). Furthermore, in the chi-square test for analysing the association of the likelihood of positive *E. coli* growth across HCWs of different age groups, those aged between 28 and 38 years showed significantly more growth of *E. coli* ($p=0.035$) compared to HCWs of other age groups.

The marital state of HCP did not correlate significantly with their likelihood of having positive *E. coli* growth on their attire ($p=0.066$; Table 6). However, the ever-married people were slightly more inclined to have positive *E. coli* growths on their attire. The chi-square test showed that students were significantly less likely to have positive *E. coli* growth compared to nurses and physicians ($p<0.001$). Interestingly, the HCP working in critical care had significantly less positive *E. coli* growth on their attire compared to those working in other departments ($p=0.002$). HCP working in surgical floors showed less positive *E. coli* growths, but those working in the emergency room or treating outpatients showed more positive *E. coli* growth on their attire.

In Figure 3, the odds of having *E. coli* growth on the attire has been depicted on the y-axis, and HCPs' working/training area has been depicted on the x-axis. It is clear that people working in emergency rooms and outpatient areas are the most susceptible, followed by those in medical and surgical floors and then those in critical care.

Moreover, the duration of experience of HCP correlated significantly with the probability of having positive *E. coli* growth on their attire ($p=0.022$). The chi-squared test showed that those with an experience of 2 to 5 years were more likely to have *E. coli* growth on their attire. The monthly income of HCP's households correlated significantly with their likelihood of having *E. coli* growth on their attire ($p<0.001$). People with an income of 600–800 JOD were significantly more inclined to have positive *E. coli* growth swabs ($p<0.001$) than the other HCP with different monthly income levels of the households. Nonetheless, a standardized socioeconomic index score was computed using the factor analysis procedure comprising the HCP's income, age, marital status, and living conditions. The mean socioeconomic index score differed significantly between people with and without *E. coli* growth on their attire. Those who had the growth showed a higher socioeconomic index score compared to those who did not ($p=0.004$; Table 6).

Moreover, HCP with family size of 4 to 6 members were significantly more likely to have *E. coli* growth on their hospital attire ($p=0.012$), according to the chi-squared test. However, the analysis results suggested that the residence type of HCP did not correlate significantly with their probability of positive *E. coli* growth on their hospital attire ($p=0.406$). HCP living in houses shared with their spouse, kids, and parents were slightly more likely to have positive *E. coli* samples on their hospital attires (Table 6).

Table 6 shows the bivariate analysis results for the association between HCP's attire characteristics and hygienic practices with the likelihood of having *E. coli*-positive samples on various attire sites. The

analysis outcomes suggested that the HCP using various types of uniforms did not differ with respect to their attire growing *E. coli* ($p=0.550$). Moreover, their rate of washing the attire did not correlate significantly with their likelihood of having positive *E. coli* samples on their attire sites ($p=0.957$). Furthermore, HCP's hygiene and attire characteristics and practices (namely the number of lab coats, washing frequency of lab coats, age of lab coats, borrowing lab coats from other workers, reasons of wearing lab coats, and the way they handle them besides the laundry service used for their attire) correlated with their likelihood of having *E. coli* samples on their attire ($p>0.050$ each). However, the chi-squared test suggested that the HCP who store their attire in the hospital were significantly more inclined to show positive *E. coli* samples on various attire sites compared to those who stored their attire at home ($p=0.002$). Moreover, the analysis suggested that HCP who cared for 10 to 15 patients per day were significantly more likely to have positive *E. coli* samples compared to other HCP who deliver care to <10 patients per day or those who care for >15 patients per day ($p<0.001$). Storing the lab coat at the hospital correlated significantly with a higher incidence of positive *E. coli* samples on the attire ($p=0.039$). Likewise, the HCP who wore their uniforms outside hospital settings were found to be significantly more likely to have positive *E. coli* samples on their attire ($p=0.005$). Those who disagreed with the ability of hospital attire to transmit pathogens were slightly more likely to have positive *E. coli* samples on their attire ($p=0.081$), according to the chi-squared test of independence.

Discussion

In our study, *Enterococcus faecalis* was the most common species of bacteria found on healthcare personnel attire. Notwithstanding, *Enterococcus* usually does not cause health problems in healthy people, unless it has spread to other areas of the body which might cause life-threatening infections,²¹ such as endocarditis, sepsis, urinary tract infections (UTIs), and meningitis.²²

E. faecalis is found in a wide variety of environments, including soil, water, and human and animal gastrointestinal tract. In our study, the source of *E. faecalis* contamination in healthcare personnel attire might be due to poor hospital surface disinfection, personal hygiene, or both. Moreover, *E. faecalis* is able to survive on dry surfaces for nearly a week to four months, depending on the strain as stated by Wendt and colleagues.²³ Whereas, *Staphylococcus aureus* was the most common contamination agent on lab coats in studies conducted in Moshi, Tanzania²⁴ and Mansoura, Egypt²⁵, which contradict the results obtained in the current study. In our study, the presence of *E. coli* varied based on the location on the lab coat. In the literature, it has been associated with numerous diseases, such as inflammatory bowel disease²⁶, Crohn's disease²⁷, UTIs²⁸, and pediatric acute diarrhea.²⁹

In the current study, the distribution of bacterial growth was highest on the mid-sleeve area healthcare personnel attire, in which mid-sleeves are close to the sides of uniforms. This is in concordance with what was found in the study conducted by Banu and colleagues³⁰. They reported that the sides of the coats were the most highly contaminated areas compared to the collar and pockets. The mid-sleeves might be contaminated when resting arms on nurse stations or reception desks while documenting activities. Mid-

sleeve areas are the prominent parts of the body that might touch surrounding environment while moving and ambulating. *E. coli* was found to be the highest in the collar area of the lab coat in the current study. This might be due to transmission from the perineal area to the collar because of a bad washing habit and changing of lab coats in bathrooms.

To the best of our knowledge, the current study only reveals the correlation between the age of healthcare personnel and the bacterial contamination on their attire. This study indicated that healthcare personnel aged ≥ 36 y had higher bacterial contamination in their attire compared to those in other age groups. Younger healthcare personnel possibly tend to change and clean their attire more frequently. In contrast, *E. coli* was found to be the highest in the attire of HCP aged between 28 and 36 years, which might be due to the frequent use of bathrooms among younger HCWs.

The attire of female healthcare personnel had higher bacterial contamination than those of male personnel, which is different from what was reported by Akanbi and colleagues.¹⁵ Their study revealed that lab coats of male resident doctors were more contaminated compared to female resident doctors. The justification of the results in our study is that most of allied health students, including female allied health students, have only one place, which is bathrooms, to change their dresses due to the lack of specialized dressing rooms. This was supported by what was observed during the data collection stage as reported by Dir and colleagues³¹. In their study, they observed that many people attended the bathroom while wearing their lab coats. Similarly, female HCP attires were highly contaminated with *E. coli* compared to their male counterparts in this study. UTIs caused by *E. coli* is more common in women³², which raises concerns about female HCP being prone to UTI from their attires.

Allied health students' uniforms, in our study, had lower contamination compared to those of physicians, which could be due to the higher adherence to university official code of tidy and clean lab coats/scrubs by the students than by the physicians. This result might be unanticipated compared to what was reported by Muhadi and colleagues,³³ who demonstrated higher contamination in allied health students' attire and that allied health students use lab coats outside the hospital premises, resulting in the higher contamination levels of their lab coats, particularly *E. coli* growth on nurses' attires and those working on medical floors. The type of HCP working department in our study also showed a significant role in causing higher contamination of the attire among HCP working in critical care units compared to the emergency department. In concordance with the role of the department in bacterial contamination, the surgery department was found to predispose its HCP to the highest degree of contamination, as reported by Akanbi and colleagues.¹⁵

In the current study, white lab coats were more contaminated compared to scrubs, which in turn, raised questions about the importance of wearing white lab coats in settings where patients received healthcare. This was also recommended by Qaday and colleagues,²⁴ in which lab coats should not be recommended to use anymore. Although Banu and colleagues reported that the possession of two or more white lab coats reduced contamination compared to the possession of only one,³⁰ our study results showed the opposite—that those who possess two lab coats were more contaminated. This might be due to failure to

keep track of which lab coat needs to be cleaning. This result could be also justified that HCP might clean their only one lab coat frequently compared to who possess several lab coats. Hygienic practices of lab coats/scrubs might be considered more important than the number of uniforms that HCP possess in terms of bacterial contamination on uniforms.

Borrowed lab coats/scrubs from others in the current study had high contamination, which necessitates the compulsory policy of possession at least two coat/scrub for each HCP as well as yearly purchase of lab coats/scrubs and banning the borrowing lab coats from each other as this item is strictly personal.³⁴ In addition, due to the borrowing of these attire, the owners of lab coats/scrubs cannot keep track of where these lab coats were used and when they should be washed. Despite the recommendation that lab coats/scrubs should be stored within hospital premises³⁵ and washed regularly because of continuous bacterial contaminations within a few hours of usage, the current study revealed that *E. coli* grew on attires stored in hospital lockers more than those stored at homes. A washing facility on the hospital premises is a must to keep the lab coats clean and cut the chain of contamination of nosocomial pathogens, even after newly laundered uniforms.³⁶ It was shocking that the positive growth of *E. coli* on attires were associated with the number of cared/examined patients per day (more than ten patients) by HCP in our study. Such contamination of *E. coli* predisposes patients to *E. coli* bacteremia, which in turn leads to adverse health outcomes, such as increased length of stay and cost of those patients³⁷ as well as advanced colorectal neoplasia³⁸. As a result, infection control starting with combating contamination with *E. coli* and its strains should be structured and adhered to by HCP as part of their efforts in eradicating nosocomial infections^{39–41}. Subsequently, further steps should be antimicrobial susceptibility testing to contribute significantly in the treatment of nosocomial infections for patients in the healthcare departments⁴².

Conclusions

The use of white lab coats develops more concerns pertinent to its role in transmission healthcare-associated infection compared to use of scrubs. HCP are in urgent need to recognize the risk factors and behaviors that contribute to healthcare-associated infection through use of lab coats, not merely hygienic handling of lab coats, but awareness of places or hospital premises where lab coats should be used. HCP, including physicians, nurses, and allied health students, should be cautious on how and where lab coats should be brought and worn.

Abbreviations

E. coli: Escherichia coli

HCP: Healthcare personnel

Declarations

Ethics approval and consent to participate

The Institutional Review Boards of Jordan University of Science and Technology (IRB #.20180170) and Consenting participants signed a written consent form.

Consent for publication

Not Applicable

Availability of data and material

Not applicable

Competing interests

All authors have no financial and non-financial competing interests

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Authors' contributions

We hereby confirm that all listed authors meet the authorship criteria and that all authors are in agreement with the content of the manuscript.

Study conception & design: AH; data collection and analysis: AH, ZJ, EA, MA; data interpretation: AH, ZJ; and manuscript preparation: AH, ZJ; final approval of the manuscript version to be published: AH.

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Conflict of Interest

All authors declare that they have no conflict of interest.

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Authorship Statement

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Study conception & design: AH; data collection and analysis: AH, ZJ, EA, MA; data interpretation: AH, ZJ; and manuscript preparation: AH, ZJ; final approval of the manuscript version to be published: AH.

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Tables

Table.1: Descriptive analysis of the healthcare personnel sociodemographic and professional characteristics (N=188).

Parameter	N (%)	Mean (SD)
Age (years)		28.07 (5.67)
Gender		
Male	80 (42.6)	
Female	108 (57.4)	
Age groups		
19-27 years	99 (52.7)	
28-35 years	70 (37.2)	
36-43 years	19 (10.1)	
Marital state		
Never married	100 (53.2)	
Ever married	88 (46.8)	
Profession		
Medical Students	59 (31.4)	
Nurses	69 (36.7)	
Physicians	60 (31.9)	
Department		
Surgical floor	41 (21.8)	
Medical Floor	63 (33.5)	
Critical Care Unit	33 (17.6)	
Outpatient clinics and auxiliary departments	24 (12.8)	
Emergency Department	27 (14.4)	
Experience years		
≤1 years	56 (29.8)	
2-5 years	56 (29.8)	
>5 years	76 (40.4)	
Households income/month (JOD)		
< 400 JOD	59 (31.4)	
400_600 JOD	50 (26.6)	

600_800 JOD	57 (30.3)
>800 JOD	22 (11.7)
Households size (Family members)	4.15 (2.3)
1-3 members	81 (43.1)
4-6 member	75 (39.9)
≥7 members	32 (17)
Living /rooming with	
Alone	18 (9.6)
Spouse Only	25 (13.3)
Spouse and sons/daughters	54 (28.7)
Spouse, sons/daughters & Parents	51 (27.1)
Others	40 (21.3)

Note: Medical students are medicine, nursing and pharmacy students.

Table.2: Descriptive analysis of the handling behaviors and washing practices of uniforms/ lab coats (N=188).

	N (%)	Mean (SD)
Type of uniform used		
lab coat	95 (50.5)	
Scrub	93 (49.5)	
Number of owned uniforms/Lab coats		2.10 (0.82)
How often do you wash/laundry your used uniforms (times/months)		7.42 (6.86)
1-4 times/Months	104 (55.3)	
5-10 times/Months	41 (21.8)	
11-16 times/Months	30 (16)	
≥17 times/Months	13 (6.9)	
How many uniforms/lab coats do you have		
One	56 (29.8)	
Two	62 (33)	
Three	70 (37.2)	
How often do you wash your uniform/ lab coat		
Once/ 3 days	78 (41.5)	
Once/week	78 (41.5)	
Every two weeks	27 (14.4)	
Once per month or more	5 (2.7)	
Where you store your uniform/lab coat.		
Hospital locker	100 (53.2)	
Home	88 (46.8)	
How many years have you been using the same uniforms/lab coats		
< 1 year	102 (54.3)	
1-2 years or more	86 (45.7)	
Do you borrow uniforms/lab coats from work peers sometimes		
No	163 (86.7)	
Yes	25 (13.3)	
Number of cared/examined patients per day		

<10 patients	69 (36.7)
10-15 patients	52 (27.7)
>15 patients	67 (35.6)
Reasons for wearing your uniform/lab coat	
To cover clothes/keep warm	21 (11.1)
For professional attire/code of dress	156 (83)
Other reasons	11 (5.9)
How you carry your uniform/lab coat once you finish your clinical day	
Covered	31 (16.5)
In a bag	58 (30.9)
In hands	99 (52.7)
Where do you wash your uniforms/lab coat	
laundry	33 (17.6)
Home	153 (81.4)
Both	2 (1.1)
Where do you store/keep your used uniform/lab coat	
Hospital	88 (46.8)
Home/hostel	100 (53.2)
Do you believe that white coats can be a potential transmitting agent for pathogens	
No	7 (3.7)
Yes	181 (96.3)
Do you wear a uniform/lab coat outside hospital/clinical areas	
No	151 (80.3)
Yes	37 (19.7)

Table.3: Descriptive analysis of the types of bacteria on the HCPs' uniforms/lab coats (N=188).

	N (%)	Mean (SD)
<i>Enterococcus faecalis</i>	122 (77.7)	
<i>Staphylococcus aureus</i>	49 (31.2)	
<i>Escherichia coli</i>	44 (28)	
<i>Pseudomonas aeruginosa</i>	8 (5.1)	
Total number of positive grown CFUs		9.81 (4.46)
Total number of non-identified bacterial types		2.42 (1.08)
Bacterial CFU counts per location		
Location-A CFU's= Collar		3.22 (1.69)
Location-B CFU's= Mid-sleeve		3.32 (1.79)
Location-C CFU's= Waist		3.27 (1.77)

Note: CFU: Colony Forming Units

Table.4: Descriptive analysis of the isolated positive growth bacterial types from three attire locations (N=188).

	Total	Collar N(%)	Mid-Sleeve N(%)	Waist N(%)	test statistic	p- value
<i>Enterococcus fecalis</i>	203	64 (65.3)	63 (66.3)	76 (73.1)	$\chi^2_{(2)}=2.99$	0.224
<i>Staphylococcus aureus</i>	68	24 (24.5)	20 (21.1)	24 (23.1)	$\chi^2_{(2)}=0.681$	0.711
<i>Escherichia coli</i>	74	30 (30.6%)	18 (18.9)	26 (25)	$\chi^2_{(2)}=5.74$	0.057
<i>Pseudomonas aeruginosa</i>	11	2 (2%)	6 (6.3)	3 (2.9)	$\chi^2_{(2)}=3.25$	0.197

Note: Cochran Q-Chi squared test for related samples

Table 5: Multivariate generalized linear “mixed effects gamma” regression analysis of attire hygiene characteristics of their measured total colony forming unit counts measured from three attire locations (N=564).

Parameter		95% C.I Beta coefficient					
		Beta coefficient	Std. Err.	t-value	Lower	Upper	p-value
Intercept		2.663	0.125	21.310	2.417	2.908	<0.001
Age groups	19-27 years old	0.056	0.064	0.877	-0.069	0.181	0.381
	28-35 years old	-0.137	0.059	-2.31	-0.254	-0.021	0.021
	36-43 years reference	0					
Gender	Male	-0.112	0.041	-2.412	-0.197	-0.031	0.007
	Female reference						
Monthly income	< 400 JOD	-0.154	0.064	-2.56	-0.272	-0.036	0.011
	400-600 JOD	-0.058	0.06	-0.969	-0.175	0.06	0.333
	600-800 JOD	-0.023	0.054	-0.4129	-0.13	0.084	0.675
	>800 JOD reference	0					
Occupation	Medical students	-0.181	0.045	-4.001	-0.27	-0.092	<0.001
	Nurses	0.066	0.052	1.255	-0.037	0.168	0.168
	Physicians reference	0					
Department	Surgical ward	-0.007	0.06	-0.118	-0.125	0.111	0.906
	Medical ward	-0.018	0.055	-0.322	0.127	0.091	0.747
	Critical care units	0.283	0.06	4.678	0.164	0.401	<0.001
	Outpatient and auxiliary clinics	-0.014	0.057	-0.254	-0.126	0.097	0.8
	Emergency department reference						
Living with sons/daughters	Alone	0.225	0.064	3.531	0.1	0.351	<0.001
	Spouse only	0.128	0.072	1.781	-0.013	0.269	0.076
	Spouse & sons/daughters	0.119	0.051	2.331	0.019	0.22	0.020
	Spouse & sons/daughters & parents	0.064	0.052	1.24	-0.037	0.165	0.215
	Others reference	0					

Uniform type	lab coat	-0.124	0.05	-2.474	-0.222	-0.025	0.014
	Scrub ^{reference}	0					
Num. of uniforms	One	-0.174	0.044	-3.989	-0.259	-0.088	<0.001
	Two	-0.027	0.037	-0.731	-0.099	0.045	0.465
	Three ^{reference}	0					
Borrows uniform	No	-0.092	0.05	-1.829	-0.191	0.007	0.068
	Yes ^{reference}	0					
Carrying method	Covered	0.121	0.044	2.762	0.035	0.207	0.006
	In a bag	-0.1	0.044	2.294	-0.186	-0.014	0.022
	By hand ^{reference}	0					
<i>Note:</i> Link function: Log under Gamma distribution; Model Information Criteria: Akaike's; AIC=608.44; Bayesian BIC=616.99; p<0.001; Random effect= Subject ID X site of the sample.							

Table 6: Bivariate Analysis of the association between E. coli positive growth with the HCW's sociodemographic factors, uniform and lab coat using and handling behaviors (N=564).

	Attire Escherichia coli positive			
	No Mean (SD)/N (%)	Yes Mean (SD)/N (%)	tests statistic	p-value
Gender				
Male	217 (44.3)	23 (31.1)	$\chi^2 (1) = 4.59$	0.032
Female ^{reference}	273 (55.7)	51 (68.9)		
Age (years)	27.920 (5.82)	29.10 (4.35)	$t(116.60) = 2.01$	0.046
Age groups				
19-27 years	268 (54.7)	29 (39.2)	$\chi^2 (2) = 6.71$	0.035
28-35 years	173 (35.3)	37 (50)		
36-43 years	49 (10)	8 (10.8)		
Marital state				
Never married	268 (54.7)	32 (43.2)	$\chi^2 (1) = 3.39$	0.066
Ever married	222 (45.3)	42 (56.8)		
Profession/occupation				
Medical Students	171 (34.9)	6 (8.1)	$\chi^2 (2) = 21.44$	<0.001
Nurses	171 (34.9)	36 (48.6)		
Physicians ^{reference}	148 (30.2)	32 (43.2)		
Department				
Surgical floor	109 (22.2)	14 (18.9)	$\chi^2 (4) = 17.33$	0.002
Medical Floor	164 (33.5)	25 (33.8)		
Critical Care Unit	95 (19.6)	3 (4.1)		

Outpatient clinics and auxiliary departments	57 (11.6)	15 (20.3)		
Emergency department ^{reference}	64 (13.1)	17 (23)		
Experience years				
<=1 years	155 (31.6)	13 (17.6)	$\chi^2 (2) = 7.62$	0.022
2_5 years	138 (28.2)	30 (40.5)		
>5 years	197 (40.2)	31 (41.9)		
Monthly income				
< 400 JOD	165 (33.7)	12 (16.2)	$\chi^2 (2) = 21.66$	<0.001
400-600 JOD	135 (27.6)	15 (20.3)		
600-800 JOD	132 (26.9)	39 (52.7)		
>800 JOD ^{reference}	58 (11.8)	8 (10.8)		
Households size (members)				
1-3 members	215 (43.9)	28 (37.8)	$\chi^2 (2) = 8.8$	0.012
4-6 member	185 (37.8)	40 (54.1)		
>=7 members	90 (18.4)	6 (8.1)		
Socioeconomic index score	-0.047 (1.01)	0.311 (0.89)	$t (562) = 2.89$	0.004
Living with				
Alone	50 (10.2)	4 (5.4)	$\chi^2 (4) = 4$	0.406
Spouse only	68 (13.9)	7 (9.5)		
Spouse & sons/daughters	141 (28.8)	21 (28.4)		
Spouse & sons/daughters & parents	128 (26.1)	25 (33.8)		
Others ^{reference}	103 (21)	17 (23)		
Uniform type				

lab coat	250 (51)	35 (47.3)	$\chi^2 (1) = 0.36$	0.550
Scrub ^{reference}	240 (49)	39 (42.7)		
Washing/laundry times				
1-4 times/Months	270 (55.1)	42 (56.8)	$\chi^2 (3) = 0.320$	0.957
5-10 times/Months	107 (21.8)	16 (21.6)		
11-16 times/Months	78 (15.9)	12 (16.2)		
>=17 times/Months	35 (7.1)	4 (5.4)		
Num. of uniforms				
One	141 (28.8)	27 (36.5)	$\chi^2 (2) = 2.67$	0.263
Two	167 (34.1)	19 (25.7)		
Three ^{reference}	182 (37.1)	28 (37.8)		
Frequency of lab coat washing				
Once/ 3 days	202 (41.2)	32 (43.2)	$\chi^2 (3) = 0.13$	0.989
Once/week	204 (41.6)	30 (40.5)		
Every two weeks	71 (14.5)	10 (13.5)		
Once per month or more	13 (2.7)	2 (2.7)		
Storing lab coats				
Hospital locker	248 (50.6)	52 (70.2)	$\chi^2 (1) = 9.98$	0.002
Home	242 (49.4)	22 (29.7)		
Borrows uniform				
No	424 (86.5)	65 (87.8)	$\chi^2 (1) = 0.10$	0.758
Yes ^{reference}	66 (13.5)	9 (12.2)		
Number of cared/examined patients per day				
<10 patients	199 (40.6)	8 (10.8)	$\chi^2 (2) = 31.23$	<0.001

10_15 patients	119 (24.3)	37 (50)		
>15 patients	172 (35.1)	29 (39.2)		
How long have you been using the same lab coats				
<1 year	270 (55.1)	36 (48.6)	$\chi^2 (1) = 1.08$	0.299
1-2 years or more	220 (44.9)	38 (51.4)		
Reasons for wearing lab coats				
To cover clothes/waring	56 (11.4)	7 (9.5)	$\chi^2 (2) = 3.57$	0.168
For professional attire/ dress code	402 (82)	66 (89.2)		
Other reasons	32 (6.5)	1 (1.4)		
Carrying method				
Covered	83 (16.9)	10 (13.5)	$\chi^2 (2) = 4.10$	0.130
In a bag	157 (32)	17 (23)		
By hand ^{reference}	250 (51)	47 (63.5)		
Place of laundering/washing				
Hospital laundry	88 (18)	11 (14.9)	$\chi^2 (2) = 2.20$	0.333
Home	396 (80.8)	63 (85.1)	LR	
Both	6 (1.2)	0		
Place of storing				
Hospital	221 (45.1)	43 (58.1)	$\chi^2 (1) = 4.37$	0.037
Home/hostel	269 (54.9)	31 (41.9)		
Do you believe that white coats can be a potential transmitting agent for pathogens				
No	21 (4.3)	0	$\chi^2 (1) = 2.21$	0.137
Yes	469 (95.7)	74 (100)	YATES	
Wearing a lab coat outside clinical areas.				

No	388 (79.2)	65 (87.8)	$\chi^2 (1) = 3.10$	0.081
Yes	102 (20.8)	9 (12.2)		

Figures

Figure 1

The mean of bacterial growth CFUs measured from three bodily sites of the HCPs' attire

Figure 2

The association between HCP working unit and their attire total recovered Mean-Log(CFU) counts

Figure 3

The odds of measuring a positive E. coli from the attire of HCP coming from various working units