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Title: Welcome to the wards: Pilot study on microbial contamination of medical students during initial clinical rotations

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Abstract

Background: Pathogenic bacteria can colonise the hands, medical equipment, and personal belongings of healthcare workers (HCW) exposed to clinical environments. Healthcare-associated infections (HAI) arising from the transmission of these pathogens to patients causes morbidity, mortality, and an economic burden. Despite widespread healthcare worker education and policy change, the incidence of HAI remains high in Australia.

Aim: To identify potentially pathogenic bacterial contamination of clinically unexposed medical students' hands and items upon entry into the clinical environment and subsequent design of a definitive study.

Materials and methods: A pilot prospective cohort study was performed at a large tertiary hospital in Melbourne, Victoria. Eight medical students had two- to six-week samples taken from their dominant hand, mobile phones, and stethoscopes in the first six months of entering the clinical environment.

Results: Pathogenic bacteria were detected throughout the six-month testing period on five of the eight students' hands, mobile phones, or stethoscopes. Pathogenic bacteria grown included methicillin-sensitive *Staphylococcus aureus, Enterococcus faecalis,* and Gram-negative pathogens, such as *Serratia marcescens, Pseudomonas* spp. and *Acinetobacter baumanii*. No multi-resistant organisms were detected. Low decontamination rates of items, universal use of phones while on the toilet, and recent hand hygiene credentialing were reported by participants.

Conclusion: Colonisation by nosocomial pathogens on medical students' hands, mobile phones, and stethoscopes was identified during the first six months of clinical study. Further research to characterise bacterial contamination of new HCW, risk factors, and strategies to improve infection control practices has the potential to reduce HAI.

Learning points:

1. Upon entering the clinical environment, medical students can be quickly colonised by pathogenic bacteria which poses a risk of transmission to patients.
2. Mobile phones were frequently found to be contaminated but infrequently cleaned, which raises questions on adequacy of education regarding mobile phone decontamination.
3. Hand hygiene is a personal duty and a priority of patient care which requires the support of healthcare institutions and community awareness to encourage compliance.

Introduction

Ever since Antonie van Leeuwenhoek first observed bacteria through his microscope in the 1670s [1], healthcare workers (HCWs) have studied the colonisation of our bodies and equipment with microorganisms and subsequent transmission to others [2]. In fact, roughly 20-40% of all hospital acquired infections (HAI) have been attributed to cross-infection from the hands or equipment of HCWs [3]. Currently, one in ten acute adult hospitalised patients in Australia has a HAI [4] despite widespread understanding that correct hand hygiene practices reduce the transmission of HAI by a third.

As medical students transition to a clinical hospital environment, their microbiota changes [5]. However, there are insufficient data regarding the time required for HCWs to become colonised by hospital pathogens. Existing cross-sectional studies involve participants who have had years of exposure to the clinical environment [2, 3, 6, 7]. Junior medical students comprise a population of HCWs with minimal exposure to the clinical environment and new medical equipment.

In this pilot prospective cohort study, a group of eight medical students were followed through their induction into the clinical environment with regular microbiological monitoring. The primary aim was to identify potentially pathogenic bacterial contamination of clinically unexposed medical students' hands and items as well as the acquisition of multi-resistant organisms (MRO), guiding subsequent design of a definitive study.

Methods

Study design

This pilot prospective cohort study took place from February 2019 to July 2019 at a single tertiary hospital in Melbourne, Australia. Study participants consisted of eight third-year medical students, beginning their first year of clinical medicine. Participants in clinical contact with researchers were sampled opportunistically. Students subsequently rotated through various medical and surgical departments during the study period.

The study was approved as a quality assurance project by the Monash Health Human Research Ethics Committee (HERC –RES-19-0000-085Q).

Microbiological methods

Samples were self-collected from hands, mobile phones, and stethoscopes of each student at two- to six-week intervals from February to July 2019 as follows:

At each collection, direct fingerprints from each finger of the dominant hand were sampled without hand decontamination. Hand hygiene was performed using 3M Avagard 9250-P (chlorhexidine gluconate 0.5% w/v in 70% v/v ethanol) hand rub before collection of the mobile phone and stethoscope samples.

Cotton swabs moistened in sterile normal saline (0.9% w/v sodium chloride) were used to sample the front and back of students' personal mobile phones and their stethoscope diaphragms.

Hand samples were directly imprinted onto a whole horse blood agar (HBA) plate. Split horse blood/MacConkey (HBA/MAC) agar were used to culture samples from phones and stethoscopes. Participants performed their sample collection in the middle of their shift at the beginning of the working week.

Bacterial identification and antibiotic susceptibility testing

All plates were incubated at 35ºC for 48 hours aerobically. Suspect colonies of *Staphylococcus (S.) aureus, Enterococcus spp.,* and Gram-negative bacilli (GNB) were assessed for anti-microbial resistance. as per standard microbiological methods which included identification by MALDI-TOF (Matrix Assisted Laser Desorption Ionization- Time of Flight (Bruker). Antibiotic susceptibility testing specifically tested for methicillin-resistant *S. aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), and carbapenemase-producing Enterobacteriaceae (CRE).

Antibiotic susceptibility testing was performed by an experienced trained microbiologist as per laboratory methodology using VITEK® 2 (bioMérieux) microbial identification system using EUCAST (European Committee on Antimicrobial Susceptibility Testing) interpretations. MRO were defined as having acquired non-susceptibility to at least one agent in three or more anti-microbial categories [8].

Medical student demographics and risk factors for exposure

Student data were collected from de-identified questionnaires and included gender, hand hygiene certification by online training, frequency of decontamination of hands and

stethoscopes, personal illness during the six months, use of mobile phone in the lavatory, and schedule of clinical rotations.

Results

Demographics

Eight medical students in their first clinical year at a tertiary hospital in Melbourne agreed to have their hands and belongings sampled for the study period. Table 1 summarises the student demographics and clinical rotations units during this period.

All students received hand hygiene accreditation in the same year but also used their phones while in the lavatory. None of them reported other potential sources of pathogenic bacterial acquisition such as working or volunteering in other healthcare settings before starting their clinical placement. Three students suffered mild viral respiratory illnesses and gastroenteritis during the study, increasing the possibility of contamination of hands and personal items with respiratory and faecal bacteria.

Microorganisms recovered

Table 2 summarises the potential pathogenic microorganisms that were recovered from student finger imprints, phones and stethoscopes over the six-month period. No student samples grew any MRSA, VRE, or CRE during the study period and none of the isolates were multi-drug resistant.

Hand samples from Student 1 grew methicillin-sensitive *S. aureus* (MSSA) on all four occasions, and from all sample sites on one occasion. Figure 1 shows large cream MSSA colonies grown from each finger imprint on HBA and the same cream colonies growing from this student's mobile phone on HBA/MAC from collection 3. Of the other participants, only Student 8 yielded MSSA from their phone on one occasion.

Colonisation by *Serratia marcescens* was seen on Student 3's hands and mobile phone in week 1, without persistent colonisation. Subsequently, *Pseudomonas* spp. was cultured from the same student's phone on collection six.

There was a notable acquisition of environmental and nosocomial pathogens on phones, hands, and stethoscope from later collections. Gram-negative bacteria (GNB), including *Pseudomonas* spp., *Aeromonas* spp., *Acinetobacter* spp., and *Enterobacter asburiae*, were recovered in heavy growth from Student 8. Most organisms may have been acquired from the hospital environment or possibly from external aquatic and plant sources [8, 11].
There were transient colonisations of fingers and phones but less frequently stethoscopes with GNB and *Enterococcus faecalis*.

Discussion

There is a rich body of evidence that, beginning from medical school, HCWs have their mobile devices and medical equipment contaminated by pathogenic organisms [6, 7, 9, 10].

Despite the widespread implementation of hospital infection control strategies, HCWs are still colonised by pathogenic bacteria and MROs [5, 7]. In this prospective pilot study, we observed that medical students and their equipment can be contaminated by pathogenic bacteria soon after entering the clinical environment.

Previous cross-sectional studies have documented that mobile phones and the nasal and rectal mucosae of clinical year medical students can be colonised by pathogenic bacteria, such as MSSA, viridans group streptococci, *Pantoea* spp., and resistant bacteria, such as extended spectrum β-lactamase producing Enterobacteriaceae [5, 9].

In this study, HAI-associated pathogenic bacteria were isolated from five of the eight participants' hands, mobile phones, and stethoscopes during a six-month testing period. Organisms grown included MSSA, *Enterococcus faecalis* and GNB., such as *Aeromonas hydrophila*, *Pseudomonas* spp. and *Acinetobacter baumannii*. No MRO were detected.

Serratia marcescens, an opportunistic nosocomial pathogen associated with outbreaks of HAI [12] was detected on Student 3's fingers and mobile phone one month into their first rotation (Table 2). This bacterium belongs to a group of GNB called ESHCAPPM, which are characterised by inducible β-lactamases that render them resistant to cephalosporins. Bacteria in this group include *Enterobacter* spp., *Serratia* spp., *Hafnia* spp., *Citrobacter freundii* complex, *Aeromonas* spp., *Providencia* spp., *Proteus* spp. (excluding *P. mirabilis*), and *Morganella* spp. Treatment of infections caused by these bacteria with cephalosporins induced resistance to the antibiotics, risking treatment failure [11].

AmpC β-lactamase producing organisms were also acquired including *Acinetobacter baumannii*, *Acinetobacter junii*, and *Enterobacter asburiae* [13]. The plasmid-mediated AmpC β-lactamase is a cephalosporinase that hydrolyses extended-spectrum cephalosporins and is poorly inhibited by clavulanic acid. Infection often requires the use of broad-spectrum antibiotics.

Of the three surfaces sampled, the most frequently colonised surface was the hands. Intermittent, but significant, pathogens were grown from fingerprint imprints of Students 1, 6, and 8. Contaminated inanimate surfaces and direct patient shedding provides a constant source of microbial contamination for students' hands and items, which require regular decontamination [14]. Our findings suggest a degradation of clinical adherence to hand hygiene amongst the participants despite receiving prior credentialing in the same year. A re-evaluation of hand hygiene education and reinforcement methods to address the key factors may instil better practice early in students' careers. A recent Cochrane review confirmed our concerns regarding the hand hygiene compliance and suggested that further research on this topic is urgently needed [17].

The World Health Organization (WHO) has global guidelines on hand hygiene for patient safety which promote a multi-modal approach of implementation, including system change, education, evaluation, and a climate of institutional safety [15]. Community behaviour, attitudes, and peer student behaviours have been identified as the most significant factors

influencing hand hygiene compliance [16]. It would be worthwhile for institutions to create an environment and culture amongst students that encourages them to consider hand hygiene as a personal duty and a priority of patient care.

Acquisition of bacteria from personal illnesses and external sources reinforce the need for strict hand decontamination strategies. Colonisation of student 1 with MSSA most likely represented colonisation from the nose or groin microbiome to their hands [8]. Some of the bacteria identified, such as *Acinetobacter junii* and *Pantoea dispersa*, are more commonly acquired from sources external to the hospital [8].

We observed that MSSA and pathogenic GNB, such as *Serratia marcescens* and *Pseudomonas* spp., were grown from mobile phone surfaces, sometimes in the absence of hand colonisation. The literature suggests that there is heavy cross contamination between these devices and the environment [14]. Contaminated mobile phones are a potential reservoir for the re-inoculation of hands, as they provide an optimum warm environment for bacterial proliferation and are in contact with HCWs' hands in between hand hygiene, thus increasing the risk of HAI [18].

Decontamination of mobile phones and medical equipment was low amongst participants, with four out of eight participants never cleaning their mobile phones at all despite all of them having used their mobile phones while on the toilet. General awareness regarding mobile phone hygiene is lacking amongst medical students [19] and HCWs in general, with mobile phone cleaning rates as low as 10.5% in some healthcare settings [20]. As limiting the use of these items is impractical, the priority should be to identify effective decontamination strategies to improve infection control. Regular cleaning with either 70% isopropyl alcohol [21], microfibre cloths, [22] or UV disinfection devices has been found to reduce bacterial load on mobile phones [19]. There is a mounting need for the promotion of effective mobile phone cleaning in infection control guidelines.

Limitations of our study include our small sample size and short follow-up period that precluded analysis for statistical significance. There were also insufficient data correlating clinical rotations and personal illness with time of culture. Also, no baseline microbiological data were collected prior to the students' commencing their clinical year, thus limiting our ability to comment on acquisition at the first collection. Lastly, due to human resource shortages, samples were self-collected which could introduce significant variability of microbiological data.

A definitive study would have an increased sample size and stricter sampling protocols. The aim would be to demonstrate a statistically significant increase in student colonisation with resistant organisms over time. Potentially, a control group of students of another discipline, not exposed to the hospital could be added.

Conclusion

This study revealed that the colonisation of medical students' fingers, stethoscopes, and mobile phones with pathogenic bacteria occurs within the first six months of entering the hospital environment. A definitive study would allow us to better characterise the timing and pattern of bacterial contamination of new HCWs and their equipment. An analysis of infection control strategies and modifiable risk factors of transmission could have public health policy implications and be an invaluable education tool. As medical students, we

should be aware of the role we have in the acquisition and transmission of pathogens to the patients we interact with, to reduce the risk of HAI.

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Conflict of interest
The authors declare that they have no competing interests.

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Authors contribution
IW conceived the review and DK helped in the study design. YX performed the initial literature search, coordination of the study and data collection. YX, DK and IW drafted the manuscript with review and editions from RS. All authors read and approved the final manuscript.

Ethics board approval name, number, and date
The study was approved as a quality assurance project by the Southern Health Human Research Ethics Committee (HERC –RES-19-0000-085Q) in March 2019.

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