ORIGINAL ARTICLE

Scrub sink contamination and transmission to operating room personnel

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Abstract

Multiple studies have established the contamination of hospital sinks and transmission to hospital personnel. Few studies have assessed the contamination and transmission of microorganisms from the faucets of operating bay scrub sinks to operating room (OR) personnel, a potential route of infection for patients. This study aimed to investigate if there was pathogenic contamination of scrub sinks and possible transmission of those pathogens to the hands of OR personnel after preoperative hand disinfection. Swabs were taken from the hands of 50 OR personnel and from the faucets of 24 scrubs sinks at two different hospital sites, and were cultured. Hands were swabbed after completing a surgical hand scrub. Results were reported in colony-forming units per millilitre. There was significant scrub sink contamination with primarily Gram-negative organisms, such as *Delftia acidovorans* and *Sphingomonas paucimobilis*. There was no overlap in bacterial species between the cultures from hands and scrub sinks. Cultures from the sinks and the hands of the OR personnel from one site had significantly higher bacterial growth compared with the other site ($p < 0.0001$ and $p < 0.0118$, respectively). The data showed significant contamination on the faucets of operating bay scrub sinks. However, there was no observed transmission of pathogens from the scrub sinks to OR personnel, shown by the lack of overlap in bacterial species. Routine hygienic maintenance of scrub sinks is recommended.

Keywords: Contamination in operating bay, environmental contaminants, operating room personnel, preoperative hand disinfection, scrub sink

Original Submission: 6 August 2020; **Accepted:** 21 August 2020

Article published online: 1 September 2020

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Introduction

Despite advances in hospital protocols and sustained efforts to reduce contamination, nosocomial infections continue to plague the health-care system. It has been established that certain environments, such as medical devices, hospital beds and other equipment, act as reservoirs for microorganisms [1]. Cross-transmission occurs from these contaminated surfaces to patients through direct surface contact or through indirect transmission from the health-care workers who contact these surfaces [2,3]. Once transmission has occurred, bacterial colonization and infection may result.

Several studies have shown that sinks in the intensive care unit harbour communicable infectious organisms such as *Pseudomonas aeruginosa*, *Enterobacteriaceae* and *Escherichia coli* [4–6]. In a study analysing sinks in four different patient rooms, Leitner et al. found seven carbapenem-resistant *Klebsiella oxytoca* isolates that were indistinguishable from those of the patients involved in a nosocomial clonal outbreak [7]. There have also been several case reports of other water-borne pathogens such as *Delftia acidovorans* causing fatal infections within hospital systems [8–10]. These and similar pathogens possess characteristics that enable them to form biofilms and adapt to aquatic environments, which aids in the colonization of areas such as sinks [11]. These capabilities have made them notoriously difficult to eliminate, not only in patients but also in hospital environments such as building plumbing systems and fixtures

https://doi.org/10.1016/j.nmni.2020.100754

[12]. Additionally, with sufficient shearing force, these microorganisms can separate from the biofilms and cause further contamination [13]. It is clear that many different microorganisms have the capacity to colonize within certain hospital areas and be transmitted to hospital workers and patients, necessitating further evaluation and study.

Previous studies have explored the contamination of sinks throughout hospitals and the contamination of different components of the sinks, such as the sink drains, faucets and surfaces. This called into question the quality of the water and environment that hospital personnel use to disinfect their hands. The particular route of transmission of interest in this study was the transfer of pathogens from the scrub sink faucets in the operating room (OR) area to OR personnel such as surgeons and scrub technicians. We hypothesize that microorganisms in the water column and those that develop biofilms on the sink faucets are directly transferred to and contaminate the hands of OR personnel during preoperative hand disinfection. The primary organisms of concern include *P. aeruginosa*, *Klebsiella* spp., *E. coli* and *Staphylococcus* spp. because of their known virulence and presence in these zones [5–7]. Environmental organisms such as *D. acidovorans* and other Gram-negative bacilli will also be included [4,8–10]. Increased awareness of environmental reservoirs and propagation pathways of microorganisms within health-care facilities is necessary to better control bacterial load and proliferation, and possibly reduce risk of infection. The aim of this study is to investigate if there is pathogenic contamination of scrub sinks and possible transmission of those pathogens to the hands of OR personnel after preoperative hand disinfection. If the study sinks are similarly colonized relative to previous studies, we may observe microbial contamination and spread.

Materials and methods

Data gathering was performed in different operating bays at two separate hospitals, Tulane Medical Center (TMC) and Tulane Lakeside Hospital (TLH). Sample collections from participant hands and sinks were performed between 06:00 and 12:00, the start of the operating day in both facilities. Before commencement, this study received Institutional Review Board approval.

Recruitment of participants occurred through flyers, which were posted in the operating bay area and physician lounge 1 week before the collection date to notify staff that surgeons and scrub technicians were to be asked by study team members to participate in the study. Individuals were invited to participate between 06:00 and 12:00 on the collection dates by study team members and assigned a random identifier. Informed consent was obtained from participants before their inclusion in the study.

Sink sample collection

Immediately before hand sample collection, initial sample collections from the scrub sinks were performed to establish the organisms that could potentially be transmitted to personnel. Sterile swabs (BD BBL Culture Swab EZ II; Becton Dickinson, Franklin Lakes, NJ, USA) were used for sink specimen collections. The sink faucets were swabbed in a standardized manner. With light pressure, swabs were brushed around the complete circumference of the terminal rim of the faucet. Sink sample collections occurred between 06:00 and 12:00 on the two collection dates. A total of 24 sinks, 12 at each hospital site, were swabbed.

Hand sample collection

After culture samples were taken from sinks, culture samples were taken from hands. Surgeons and scrub technicians were invited to participate on an individual basis by study team members between 06:00 and 12:00 on each collection day. Each participant was then assigned a random identifier. The following inclusion criteria included: OR personnel with direct patient contact during operating procedures. Exclusion criteria included failure to adhere to hygiene protocols such as failure to perform a standard surgical scrub technique of at least 3 minutes. If criteria were met, administrators obtained consent from participants. The participants were then asked to perform a standard surgical hand scrub using Bactoshield (4% chlorhexidine gluconate). After appropriate preoperative hand disinfection, participants' hands were swabbed with BD BBL Culture Swabs. The swabbing technique involved covering the entire dorsal and palmar surfaces of both hands of the participants. The hands of 25 participants were swabbed at each operating bay location for a total of 50 samples.

Culture analysis

Samples were transferred to the hospital pathology laboratory and cultured on blood agar and MacConkey biplates to identify any traces of *P. aeruginosa*, *Klebsiella spp.*, *E. coli*, *Staphylococcus* spp., *D. acidovorans* and other virulent Gram-negative bacilli. The samples were transported to the laboratory within 1 hour after collection to limit anomalous bacterial growth. The cultures were incubated for 24 and 48 hours at 37°C. Culture diagnostics and species verification were performed on characteristic colony morphology using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry. Bacterial growth was determined quantitatively (colony-forming units (CFU)/mL).

Statistical analysis

Analysis of detectable contamination in sinks by hospital was performed using a Fisher exact test. A Wilson rank sum test

was employed to compare the counts of species in both sinks and hands at the two hospitals and a χ^2 test was used to determine detectable contamination on hands by hospital.

Results

There was no overlap in bacterial species between cultures from the hands and scrub sinks.

The number of OR personnel whose cultures exhibited bacterial growth after scrubbing in at TLH was 13 out of 25 (52%), compared with four out of 25 (16%) for TMC (p 0.0072). All 12 sinks at TLH exhibited bacterial growth (12/12; 100%), compared with 3 out of 12 (25%) at TMC (p 0.0003).

There were significant differences in bacterial growth on the sinks and hands between the two culture sites (Tables 1). The sinks at TLH had higher average bacterial counts (median 103 000 CFU/mL at TLH versus 0 CFU/mL at TMC, $p < 0.0001$). The hands of OR personnel at TLH also had significantly higher average bacterial counts (median 1 CFU/mL versus 0 CFU/mL, $p < 0.0118$).

Six identifiable bacterial species were found (Table 2). The most frequent species found on OR personnel were normal skin flora, which mostly consisted of coagulase-negative *Staphylococcus*. There was one finding of *Staphylococcus aureus* on OR personnel at TLH. The most frequent species found on sinks were *D. acidovorans*, followed by *Sphingomonas paucimobilis*, *Brevundimonas diminuta* and *Acidovorax temperans*. The remaining bacteria found were either unidentifiable on mass spectrometry or were not further verified because of being habitual skin flora.

TABLE 2. Bacterial species isolated from the hands of operating room personnel and sinks in the operating bay

	TMC		TLH	
	Hands (n = 25)	Sinks (n = 12)	Hands (n = 25)	Sinks (n = 12)
Persons/sinks with growth, n (%)	4 (16%)	3 (25%)	13 (52%)	12 (100%)
Delftia acidovorans	—	—	—	4 (33.3%)
Acidovorax temporans	—	—	—	1 (8.3%)
Sphingomonas paucimobilis	—	—	—	1 (8.3%)
Brevundimonas diminuta	—	—	—	1 (8.3%)
Staphylococcus aureus	—	—	1 (4%)	—
Coagulase-negative *Staphylococcus*	—	1 (8.3%)	—	—
Habitual skin flora	4 (16%)	—	12 (48%)	—
Unidentified	—	2 (16.7%)	—	5 (41.7%)

Abbreviations: TLH, Tulane Lakeside Hospital; TMC, Tulane Medical Center.

Discussion

Surgeons use preoperative hand disinfection at scrub sinks to prevent the transmission of microorganisms to patients, to prevent subsequent infection and to maintain a sterile environment in the OR. The purpose of this study was to explore sources of infection in the OR, specifically focusing on scrub sinks. The objective was not only to identify microorganisms found on scrub sinks and OR personnel, but also to investigate possible transmission from scrub sinks to those who scrubbed during preoperative hand disinfection.

From this investigation, the significant bacterial growth from scrub sink cultures demonstrates that the faucets of operating bay scrub sinks act as reservoirs for bacteria to survive and multiply. Our findings are consistent with previous studies that investigated hospital sinks and found mainly waterborne Gram-negative bacterial species [4,8,10]. However, when determining if there is spread from the sinks to the hands, the lack of overlap in bacterial species between the sinks and hands suggests that this route of transmission does not occur. Therefore, based on the findings of this study, we determined that there is no direct transmission of microorganism species from the faucets of contaminated sinks to OR personnel after performing a standard surgical hand scrub. An unforeseen finding in this study showed increased bacterial loads cultured from both the hands and sinks at TLH when compared with TMC, which warrants further analysis.

There are numerous possible explanations for lack of transmission from sinks to hands. Bacteria known to colonize sinks often produce biofilms to adhere to the inner surface of pipes and are resistant to laminar water flow [11,12]. Unless a sufficient physical shearing force from water or hand contact dislodges bacterial growths, transmission is unlikely [13,14]. It is possible that the sinks and water flow rates at these facilities did not provide the necessary force to displace bacteria from their

TABLE 1. Bacterial colonization of sinks within the operating bay and bacterial colonization of hands from operating room personnel

	TMC			TLH		
	n (%) growth	CFU/mL mean	CFU/mL median	n (%) growth	CFU/mL mean	CFU/mL median
Sinks (n = 12)	3 (25%)	794.7	0	12 (100%)	3.3×10^6	1×10^5
Hands (n = 25)	4 (16%)	0.84	0	13 (52%)	2.48	1

Abbreviations: TLH, Tulane Lakeside Hospital; TMC, Tulane Medical Center.

biofilms and lead to downstream contamination. The exact method that the bacteria use to disperse may play a role as well. In 2019, Kotay et al. amended a previous theory that green fluorescent protein-expressing *E. coli* aerosolizes from drains and disperses [15]. The authors recognized the substantial knowledge gap in exactly how pathogens disseminate from sink drains. There is potential that the species found on the contaminated sinks in this study use a particular method of dispersal that we did not specifically test for when using our methods of swabbing and culturing. With the variety of organisms we found, it is conceivable that some may not spread directly from the water column to hands. Furthermore, the recruitment procedure may be a confounding variable. The Hawthorne effect (observer effect) may have been present given that OR personnel were asked to participate while study administrators observed their scrub-in.

Regarding the significant differences in bacterial loads from cultures of both hands and sinks between the TLH and TMC, there may be multiple reasons. It is possible that there is a relationship between the elevated counts on hands and sinks at TLH and decreased counts at TMC, but there is also a strong possibility that it is purely coincidental. These hospitals could have baseline differences in levels of bacteria, water, cleaning supplies, metals that the faucets are composed of, equipment or cleaning schedules. All of these factors, and a multitude of others, may play into the varying bacterial loads at each facility. A more specific and standardized study design to address this particular finding is necessary to evaluate this distinction.

There were several limitations to this study. The study design did not allow for patient follow up. Future examination should focus on the relationships between flow rate of OR sinks, the use of aerators on sinks, amount of bacterial colonization on the hands of OR personnel post-scrub, and postoperative infection rates of patients at different sites. Postoperative infection rates could be correlated to bacterial loads found on contaminated hands at different sites. Furthermore, the microorganism species found in the infected patients could be compared to those found on the sinks to evaluate unforeseen transmission. Separately, the investigation of water contamination to assess contamination in more proximal areas of the plumbing system would provide relevant information. This study did not culture mid-catch water samples at either OR location.

Conclusion

Increased awareness and understanding of the environmental reservoirs of harmful microorganisms, as well as pathways of propagation, are necessary to developing methods to better control bacterial loads and transmission. The findings of this study indicate that operating bay sinks are notably contaminated with harmful microorganisms. Although we did not find evidence to support direct transmission from the sink faucets to exclusively hands, the presence of significant bacterial loads in an environment that stresses sterility is alarming. In the setting of a sterile field breach, such as a glove break, minimizing microbial presence is absolutely necessary. Further studies are necessary to help implement superior hygienic practices to improve outcomes and decrease contamination in the operating bay. Routine hygienic maintenance of scrub sinks is recommended to limit microbial occupation in the operating bay.

Financial disclosure

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Conflicts of interest

The authors certify that neither they, nor any members of their immediate family, have any commercial associations (such as consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

References

[1] Russotto V, Cortegiani A, Raineri SM, Giarratano A. Bacterial contamination of inanimate surfaces and equipment in the intensive care unit. J Intensive Care 2015;3:54.

[2] Schiffers H, Zaatreh S, Mittelmeier W, Bader R. Examination of cross contamination risks between hospitals by external medical staff via cross-sectional intercept survey of hand hygiene. GMS Hyg Infect Control 2014;9:1–9.

[3] Sergent AP, Slekovec C, Pauchot J, Jeunet L, Bertrand X, Hocquet D, et al. Bacterial contamination of the hospital environment during wound dressing change. Orthop Traumatol Surg Res 2012;98:441–5.

[4] De Geyter D, Blommaert L, Verbraeken N, Sevenois M, Huyghens L, Martini H, et al. The sink as a potential source of transmission of carbapenemase-producing *Enterobacteriaceae* in the intensive care unit. Antimicrob Resist Infect Control 2017. https://doi.org/10.1186/s13756-017-0182-3.

[5] Lalancette C, Charron D, Laferrière C, Dolcé P, Déziel E, Prévost M, et al. Hospital drains as reservoirs of *Pseudomonas aeruginosa*: multiple-locus variable-number of tandem repeats analysis genotypes recovered from faucets, sink surfaces and patients. Pathogens 2017. https://doi.org/10.3390/pathogens6030036.

[6] Kotay S, Chai W, Guilford W, Barry K, Mathers A. Spread from the sink to the patient: in situ study using Green Fluorescent Protein (GFP)-expressing Escherichia coli to model bacterial dispersion from hand-washing sink-trap reservoirs. Appl Environ Microbiol 2017;83(8):e03327-16.

[7] Leitner E, Zarfel G, Luxner J, Herzog K, Pekard-Amenitsch S, Hoenigl M, et al. Contaminated handwashing sinks as the source of a clonal outbreak of KPC-2-producing *Klebsiella oxytoca* on a hematology ward. Antimicrob Agents Chemother 2015;59:714–6.

[8] Bilgin H, Sarmis A, Tigen E, Soyletir G, Mulazimoglu L. *Delftia acidovorans*: a rare pathogen in immunocompetent and immunocompromised patients. Can J Infect Dis Med Microbiol 2015;26:277–9.

[9] Khan S, Sistla S, Dhodapkar R, Parija SC. Fatal *Delftia acidovorans* infection in an immunocompetent patient with empyema. Asian Pac J Trop Biomed 2012;2:923–4.

[10] Lang KJ, Chinzowu T, Cann KJ. *Delftia acidovorans* as an unusual causative organism in line-related sepsis. Indian J Microbiol 2012;52:102–3.

[11] Kim H, Ryu JH, Beuchat LR. Attachment of and biofilm formation by *Enterobacter sakazakii* on stainless steel and enteral feeding tubes. Appl Environ Microbiol 2006;72:5846–56.

[12] Soto-Giron MJ, Rodriguez -RLM, Luo C, Elk M, Ryu H, Hoelle J, et al. Biofilms on hospital shower hoses: characterization and implications for nosocomial infections. Appl Environ Microbiol 2016;82:2872–83.

[13] Kostakioti M, Hadjifrangiskou M, Hultgren SJ. Bacterial biofilms: development, dispersal, and therapeutic strategies in the dawn of the postantibiotic era. Cold Spring Harb Perspect Med 2013;3:1–23.

[14] Aggarwal S, Stewart PS, Hozalski RM. Biofilm cohesive strength as a basis for biofilm 2015; 2015;8:29–32.

[15] Kotay SM, Donlan RM, Ganim C, Barry K, Christensen BE, Mathers AJ. Droplet, rather than aerosol-mediated dispersion, is the primary mechanism of bacterial transmission from contaminated hand-washing sink traps. Appl Environ Microbiol 2019;85:1–12.