Int.J.Curr.Microbiol.App.Sci (2023) *12*(08): 267-274

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 12 Number 8 (2023)**
Journal homepage: http://www.ijcmas.com

Case Study https://doi.org/10.20546/ijcmas.2023.1208.028

Potential Reservoirs of Nosocomial Pathogens in a Hospital: An Investigational Study

M. K. Krishnaveni*, Anil Kumar Bilolikar and Sister Mariyamma Thomas

Film Nagar, Hakim Baba Dargah, Jubilee Hills, Hyderabad - 500 096, India

**Corresponding author*

Keywords

Patient sinks, toilets, Environmental reservoirs, water, and fomites

Article Info

Received:
02 July 2023
Accepted:
04 August 2023
Available Online:
10 August 2023

A B S T R A C T

The transmission of nosocomial pathogens in a hospital is a serious and growing concern worldwide. Environmental reservoirs could be playing a larger role in transmission than was first realized. This study evaluated environmental surveillance for nosocomial pathogens isolated from patients with hospital acquired infections. All the samples collected from the patients and environment were inoculated onto Mac Conkey Agar and 5% Sheep Blood Agar. These culture media were incubated overnight for 37°C. The growths obtained on the culture media were further processed for identification and antimicrobial susceptibility testing by Vitek 2 Compact according to manufacturer's instructions. A cluster of neurosurgical site infections post craniotomy isolated *Serratia marcescens*, which was associated with shaving razors contaminated by *S. marcescens.* In the medical ICU, 2 patients placed next to each other isolated *Burkholderia cepacia* in their blood cultures. *Burkholderia cepacia* was isolated from the rim of the sink in the handwash station. Following cardiac surgeries of two patients, both patients were infected with *Pseudomonas aeruginosa* at the surgical site. The same isolate was isolated from operation theatre overhead light handle and door handle of cardiothoracic ICU. In the paediatric ICU, *Acinetobacter baumanii* was isolated from the endotracheal secretions of two patients. Culture of water and environmental samples grew *Acinetobacter baumanii* from the oxygen vacuum jar. The environment of a hospital can contribute to hospital acquired infections. Hence, a diligent housekeeping protocol would reduce the risk of transmission of nosocomial pathogens from the environment.

Introduction

The transmission of nosocomial pathogens in hospitals is a serious and growing concern worldwide. Environmental reservoirs could be playing a large role in the chain of infection. Generally, the traditional understanding and tracking of hospital acquired infections has focused on direct contact transmission, where infected patients act as bridge of transmission between uninfected patients and hospital workers (Geehan Suleyman *et al.,* 2018). To further understand the transmission of the waterborne bacteria, hospital epidemiologists began sampling wet surfaces including patient sinks, toilets, and hoppers for the waterborne pathogens (Vergara-López *et al.,* 2013). It has become increasingly recognized that non-patient reservoirs within the hospital setting may play a larger role in the transmission of pathogens during outbreaks and ongoing sporadic transmission (Vergara-López *et al.*, 2013). Cross-transmission of these pathogens can occur via hands of healthcare workers, who become contaminated directly from patient contact or indirectly by touching contaminated environmental surfaces. Although microbiologically contaminated air, water, and fomites can serve as vehicles of transmission, demonstrating their contribution to infection and disease is difficult. This study evaluated the potential environmental sources of nosocomial pathogens upon investigation of cases with hospital acquired infections (Vergara-López *et al.*, 2013).

Materials and Methods

Case 1: Barber's kit contaminated with *Serratia marcescens*

A 55 year old male patient presented to the casualty following a road traffic accident with several injuries and loss of consciousness. Following neurosurgical evaluation, the patient was posted for emergency craniotomy. From the 5th post-op day, the patient presented with fever spikes and discharge from the surgical site. Pus samples collected from the surgical site were sent to the microbiology laboratory for culture and sensitivity. The samples were processed according to standard laboratory protocols (Collee *et al.*, 1996). The colonies were further processed for identification and antimicrobial susceptibility testing by Vitek 2 Compact as per manufacturer's instructions (Standard Operating Procedure for VITEK 2 Compact). The pus sample had isolated *Serratia marcescens* which was sensitive to meropenem, ciprofloxacin, and gentamicin. For the next 3 weeks, 4 cases underwent emergency craniotomies for varying indications. All the 4 cases presented with post op fever and discharge from the surgical site. Pus samples collected from these 4 cases at differing intervals isolated *Serratia marcescens* with exactly same sensitivity pattern. These patients were located in different wards and their operations were performed by different surgeons. The mean interval between the surgeries and culture positive was 7.2 days (3-11 days). Suspecting an outbreak, the infection control team performed a surveillance of these cases and collected 25 environmental samples from OT tables, scrub sink, soaps, soap dispensers and OT instruments. The samples were inoculated onto MacConkey agar, blood agar and fluid thioglyocollate medium and incubated overnight at 37°C. There was no growth on culture plates, rendering the samples sterile. To investigate further, another 17 samples consisting of liquid samples (medications, drip fluids, wound dressing antiseptic solutions) and environmental samples of patients' bed rail, IV stand, medication trolleys from surgical ICUs and casualty were collected for culture. These samples isolated coagulase negative Staphylococci and aerobic spore bearing bacilli. The infection control team co-ordinated with the neurosurgical team to monitor the practices and interviewed the personnel in casualty, operation theatre and ICU. Upon close monitoring, the infection control team noticed that all patients had undergone preoperative scalp shaving by the barber in the casualty. Samples were collected from the razors used in the barber's kit for culture which had isolated *Serratia marcescens,* sensitive to meropenem, ciprofloxacin, and gentamicin.

Implementation of infection control measures

Upon detection of *S. marcescens* on the razors, the use of razors for scalp shaving was completely stopped in the casualty, ward, and operating room. We recommended scalp shaving should to done with disposable clippers. Infection Control nurses performed rounds to enforce aseptic skin preparation procedures and the use of clippers. After implementation of these infection control measures, no further patients developed *S. marcescens* infections.

Case 2: *Burkholderia cepacia* living in the sink

A 68 year old male patient presented to the emergency with respiratory distress. He was already under treatment for cystic fibrosis and was admitted in the medical ICU for type 2 respiratory failure. Based on deterioration of his clinical condition and other laboratory investigations, he was admitted in the medical ICU. Though the patient was haemodynamically stable, he had febrile episodes during his stay in the ICU. Paired blood cultures were collected and sent to the microbiology lab. The cultures were incubated in the automated in BacT/Alert 3D incubator. The blood cultures isolated *Burkholderia cepacia* which was sensitive to ceftazidime, meropenem, cotrimoxazole and minocycline. Following treatment, the patient was improving clinically. Around 3 days later, the patient placed next to his bed, also presented with fever spikes.

Blood cultures were sent to the microbiology lab which also isolated *Burkholderia cepacia*, sensitive to meropenem, ceftazidime, minocycline and cotrimoxazole. To arrest an impending outbreak of *Burkholderia cepacia* in the medical ICU, the infection control team performed a field investigation by collecting 24 environmental samples consisting of liquid solutions used in the ICU, hand wash soap solutions, hand wash station tap water, sink rim, ultrasound and ECG gels. The samples were inoculated on routine culture media and the growths obtained were processed according to standard laboratory protocols. *Burkholderia cepacia* was isolated from hand wash sink rim which is sensitive to meropenem, ceftazidime, minocycline and cotrimoxazole.

Implementation of infection control measures

The sink and other areas in the ICU were deep cleaned with mechanical scrubbing and the surfaces were disinfected with a 1% sodium hypochlorite based solution. The ICU was fogged with 11% w/v hydrogen peroxide based disinfectant. Infection control nurses trained the housekeeping staff on proper surface disinfection in the ICU. The ICU and housekeeping staff were reminded on the importance of regular disinfection and compliance to hand hygiene. Repeat environmental samples of the ICU were sterile.

Case 3: Surgical site infections by *Pseudomonas aeruginosa* in cardiac patients

In the month of March 2022, a patient who underwent cardiac surgery came for a review follow up with complaints of fever, pain and discharge from the sternal surgical site. Pus sample was collected and sent for culture and sensitivity testing. The sample isolated *Pseudomonas aeruginosa* which was sensitive to ceftazidime, imipenem and meropenem. In the next one month, 2 cases who underwent cardiac surgeries presented with similar complaints. Pus samples of these 2 cases also isolated *Pseudomonas aeruginosa* with a similar sensitivity pattern. The infection control team interviewed the cardiothoracic operation theatre staff.

Based on the discussions with them, environmental samples were collected from cardiothoracic operation theatre (OT) such as OT table, door handle, overhead light, liquid solutions, hand wash station, anaesthetic equipment. Along with these environmental swabs were also collected from the cardio-thoracic ICU which were bed rails, medication trolleys, liquid solutions, door handle, ECG machine, ECG gel and oxygen flow meter. These samples were processed according to standard laboratory procedure. OT overhead light dome, light handle and CT-ICU door handle isolated *Pseudomonas aeruginosa* which was sensitive to ceftazidime, imipenem and meropenem.

Implementation of infection control measures

The findings of the surveillance were communicated to the cardiaothoracic surgery department. Housekeeping staff were trained on appropriate and frequent disinfection of the OT and ICU. OT in-charge was instructed to strictly maintain a contact time of 15-30 minutes following disinfection between each OT along with documented proof. Cardiothoracic OT was deep cleaned with vigorous mechanical scrubbing and fogged with an hydrogen peroxide based disinfectant. The same was followed for cardiothoracic ICU. Samples were again collected which were sterile. No cluster of surgical site infections from the cardiothoracic surgery unit were reported after this.

Case 4: *Acinetobacter baumanii* isolated from pediatric ICU

In the pediatric intensive care unit (PICU), endotracheal secretions of a baby was sent for culture. It isolated *Acinetobacter baumanii* which was sensitive to minocycline, tigecycline, and cotrimoxazole. Three days later, another intubated patient in the PICU showed signs of respiratory infection. His endotracheal secretions also isolated *Acinetobacter baumanii,* sensitive to minocycline, tigecycline, and cotrimoxazole. The infection control team performed an environmental surveillance, particularly emphasizing the respiratory devices (ventilatory equipment, humidifiers, oxygenation, nebulizers, CPAP) along with other areas such as patient's bed rails, IV stands, monitors, and stethoscopes. The collected samples were processed according to standard laboratory protocols. It was found that *Acinetobacter baumanii* was isolated from the oxygen vacuum jars of both the infected patients with similar sensitivity pattern.

Implementation of infection control measures

Personnel interview of the housekeeping staff on disinfection of the jars did not show any major deviations from the institute's protocols. However, to strengthen cleaning/disinfection protocols, housekeeping staff were given the following instructions: Perform hand hygiene, wear appropriate personal protective equipment, empty the oxygen vacuum jar, wash it with a mild detergent and warm water.

Then, freshly prepare a 1% sodium hypochlorite solution in a well ventilated area, away from the patient's surroundings and wet wipe the jar with this solution from top to bottom, inside and outside, including the rim of the jar to ensure complete disinfection of the jars. The jars should be kept away where there is low risk of contamination. If the jars are to be used immediately, they must ensure a contact time of at least 1 minute after the application of the disinfectant before the next use.

Results and Discussion

Disclaimer: Whole-genome sequencing was not done for the isolates in this study due to financial, administrative and resource limitations. Similarity between the organisms was identified based on bionumber in Vitek 2 Compact.

Non-patient reservoirs may play a role in transmitting hospital acquired infections. Waterborne bacterial hospital acquired infections have led to hospital epidemiologists begin sampling of wet areas like sinks, toilets and liquid solutions (Vergara-López *et al.,* 2013). Within the hospital settings, drains, sinks, and faucets are usually colonised. And these sites are most commonly colonised with *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (Alice E. Kizny Gordon *et al.,* 2017). Although there are no statutory guidelines stating that the hospital environment does transmit infections, recent studies have shown that environmental contamination does play a role in transmission of nosocomial pathogens during outbreaks, as well as ongoing sporadic transmission (Suleyman *et al.,* 2018).

Neurosurgical site infections occur in about 5% of patients post craniotomy (Edwards *et al.,* 2009). Many surgeons believe that hair removal facilitates easy visualization of the surgical site and reduces the risk of surgical site infections. The results of some randomized controlled trials revealed no differences in the rate of surgical site infections between patients with and without hair removal before surgery (Tanner *et al.,* 2011). A meta-analysis of Seven studies showed that shaving had neither benefit nor harm when compared to no hair removal (WHO). In an article published in 2020 on Outbreak investigation of *Serratia marcescens* in neurosurgical site infections, Kim *et al.,* (2020) have stated that contaminated razors and brushes were the sources of the outbreak. In a systematic review by WHO on the use of razors and clippers, a meta analysis of these 4 studies showed that there is a significantly lower risk of SSI following hair removal with clippers when compared to shaving (WHO). In this scenario, the infection control team advised the in-house barbers to use clippers instead of razors for pre-surgical skin preparation, following which no surgical site infections were reported from the neurosurgical unit.

Burkholderia cepacia can survive in the health care environments, fluids and antiseptic solutions for long durations. Similar to the findings of this study, Peterson *et al.,* (2013) investigated a clonal outbreak of *B. cepacia* pneumonia in patients and the sink was identified as the source which might have contaminated the respiratory care items (Peterson *et al.,* (2013). Bilgin et.al identified the chlorhexidine mouth wash as the source of an outbreak of *B. cepacia* in a tertiary care centre in Turkey (Bilgin *et al.,* 2021). This emphasizes the fact that contaminated wet surfaces may give rise to significant outbreaks.

Among endogenous and external factors, the operation theatre quality strongly influences the risk of acquiring a surgical site infection. Apart from the structural features, ventilation, water, procedural and behavioural factors, the disinfection of operation theatres (OT) and OT equipment contribute to surgical site infections. In an article by Spagnolo *et al.,* (2020) it is said that despite the use of surgical gloves, the transmission of microorganisms may occur due to microperforations in the gloves which happen at an average of 18%.

Hence, proper hand hygiene prior to the surgery is a crucial step (Gonçalves *et al.,* 2012). Pre, intra, and post handling of items in the OT like the overhead light is a common practice. Appropriate hand hygiene, adherence to 5 moments of hand hygiene, meticulous disinfection of OT and most importantly ensuring adequate contact time in between the OTs is crucial to prevention of surgical site infections.

Respiratory care equipment that include ventilators, oxygen humidifiers, and nebulisers have been identified as a potential vehicle of transmission of microorganisms (Behnia *et al.,* 2014). Bacteria may translocate to the device from the oral cavity and distal airways of a patient, or from the contamination of the water involved. Moiraghi *et al.,* (1987) reported 5 cases of fatal pneumonia caused by *Legionella pneumophila*, as a result of nebulization using contaminated humidifiers (Moiraghi *et al.,* 1987). The CDC highly recommends careful use and diligent maintenance of reusable oxygen vacuum jars (CDC, 1994).

The findings of this study do not state that the environmental sites are the sources of infection as these sites have been identified after the organisms were isolated from a patient. As there is every possibility that the organism may be translocated from the source patient to the environmental site, environmental contamination may not necessarily be the source of infection in the cases mentioned in this study. Hence, a cause-and-effect relationship could not be established in this study.Hu et al. demonstrated that biofilms of bacterial organisms are found on 52% of ICU surfaces (Hu *et al.,* 2015).

Other studies have also demonstrated the translocation of pathogens from surfaces to the hands of HCWs in the absence of direct patient contact (Otter *et al.,* 2013). In some studies investigating nosocomial outbreaks, environmental contamination has been potentially associated with the transmission of the nosocomial pathogens (Weber *et al.,* 2010). Environmental surfaces are classified under “high-touch” and “low touch” surfaces. Door knobs, bed rails, light switches, surfaces in and around toilets and curtains are included in high surfaces whereas wall, ceilings, floor and windows are included in “low touch” surfaces (Huslage *et al.,* 2010). However, the findings of this study show that surfaces like OT light handles, respiratory equipment and pre-surgical skin preparation equipment should also be focussed on for disinfection protocols.

Fig.1 OT overhead light

Fig.2 Oxygen Vacuum Jar

Though environmental disinfection has a significant role in prevention of hospital acquired infections, it comes with its own pitfalls. The challenges associated with environmental disinfection include lack of statutory guidelines on the frequency of disinfection, lack of cause-and-effect evidences, lack of knowledge on significant colony counts of environmental samples, the evolution of disinfectants from phenol to peracetic acid based solutions with overlapping spectra of activity, availability of plenty of disinfectant suppliers, inconstant housekeeping staff and the need for constant training and assessment. A robust infection control team can overcome these challenges and form a customised housekeeping and disinfection policy by identifying the trouble spots in their institute. This study concludes that the hospital environment can act as a reservoir of nosocomial pathogens and reinforcing cleaning/disinfection protocols can reduce nosocomial infections.

References

Alice E. Kizny Gordon, Amy J. Mathers, Elaine Y. L. Cheong, Thomas Gottlieb, Shireen Kotay, A. Sarah Walker, Timothy E. A. Peto, Derrick W. Crook, Nicole Stoesser, The Hospital Water Environment as a Reservoir for Carbapenem-Resistant Organisms Causing Hospital-Acquired Infections—A Systematic Review of the Literature, *Clinical Infectious Diseases*, Volume 64, Issue 10, 15 May 2017, Pages 1435–1444, https://doi.org/10.1093/cid/cix132

Behnia M, Logan SC, Fallen L, Catalano P. Nosocomial and ventilator-associated pneumonia in a community hospital intensive care unit: a retrospective review and analysis. *BMC Research Notes.* 2014;7:232–232.

Bilgin *et al. Antimicrob Resist Infect Control (2021) 10:143*. An outbreak investigation of *Burkholderia cepacia* infections related with contaminated chlorhexidine mouth wash solution in a tertiary care center in Turkeyhttps://doi.org/10.1186/s13756-021-01004-8

Centers for Disease Control and Prevention , author. Guideline for prevention of nosocomial pneumonia. *Respir Care.* 1994;39:1191–1236.

Collee, J. G., T. J. Mackie, J. E. McCartney. Mackie & McCartney practical medical microbiology. Print Book, English, 1996. Edition:14th ed. Publisher:Churchill Livingstone, New York, 1996

Edwards JR, Peterson KD, Mu Y, Banerjee S, Allen-Bridson K, Morrell G, Dudeck MA, Pollock DA, Horan TC. National Healthcare Safety Network (NHSN) report: data summary for 2006 through 2008, issued December 2009. *Am J Infect Control.* 2009; 37(10):783–805.

Geehan Suleyman, George Alangaden, Ana Cecilia Bardossy. The Role of Environmental Contamination in the Transmission. Current Infectious Disease Reports (2018) 20: 12

Gonçalves Kde J, Graziano KU, Kawagoe JY. A systematic review of surgical hand antisepsis utilizing an alcohol preparation compared to traditional products. *Rev Esc Enferm USP.* 2012;46:1484–1493.

Hu H, Johani K, Gosbell IB, Jacombs AS, Almatroudi A, Whiteley GS, *et al.*, Intensive care unit environmental surfaces are contaminated by multidrug-resistant bacteria in biofilms: combined results of conventional culture, pyrosequencing, scanning electron microscopy, and confocal laser microscopy. J Hosp Infect. 2015;91(1):35–44.

Huslage K, Rutala WA, Sickbert-Bennett E, Weber DJ. A quantitative approach to defining "high-touch" surfaces in hospitals. Infect Control Hosp Epidemiol. 2010;31(8):850–3.

Kim EJ, Park WB, Yoon JK, Cho WS, Kim SJ, Oh YR, Jun KI, Kang CK, Choe PG, Kim JI, Choi EH, Oh MD, Kim NJ. Outbreak investigation of *Serratia marcescens* neurosurgical site infections associated with a contaminated shaving razors. Antimicrob Resist Infect Control. 2020 May 12;9(1):64. doi: 10.1186/s13756-020-00725-6. PMID: 32398063; PMCID: PMC7216399.

Moiraghi A, Castellani JF, Pastoris M, Barral C, Carle F, Sciacovelli A, Passarino G, Marforio P. Nosocomial legionellosis associated with use of oxygen bubble humidifiers and underwater chest drains. *J Hosp Infect.* 1987;10:47–50.

Otter JA, Yezli S, Salkeld JA, French GL. Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and an overview of strategies to address contaminated surfaces in hospital settings. Am J Infect Control. 013;41(5 Suppl): S6–11.

Peterson AE, Chitnis AS, Xiang N, Scaletta JM, Geist R, Schwartz J, et al. Clonally related Burkholderia contaminans among ventilated patients without cystic fibrosis. Am J Infect Control. 2013;41:1298–300.

Spagnolo P, Balestro E, Aliberti S, Cocconcelli E, Biondini D, Casa GD, Sverzellati N, Maher TM. 2020. Pulmonary fibrosis secondary to COVID-19: a call to arms? Lancet Respir Med. 2020 Aug;8(8):750-752. https://doi.org/10.1016/S2213-2600(20)30222-8.

Standard Operating Procedure for VITEK 2 Compact: Use, Maintenance and Quality

Control Procedures. Office of Pesticide Programs Microbiology Laboratory Environmental Science Center, Ft. Meade, MD

Suleyman, G., Alangaden, G. & Bardossy, A.C. The Role of Environmental Contamination in the Transmission of Nosocomial Pathogens and Healthcare-Associated Infections. *Curr Infect Dis Rep* 20, 12 (2018). https://doi.org/10.1007/s11908-018-0620-2

Tanner J, Norrie P, Melen K. Preoperative hair removal to reduce surgical site infection. Cochrane Database Syst Rev. 2011;11.

Vergara-López S, Domínguez M, Conejo M, Pascual A, Rodríguez-Baño J. "Wastewater drainage system as an occult reservoir in a protracted clonal outbreak due to metallo-β-lactamase-producing *klebsiella oxytoca*," *Clinical Microbiology and Infection.* 2013;19(11):E490–E498.

Weber DJ, Rutala WA, Miller MB, Huslage K, Sickbert-Bennett E. Role of hospital surfaces in the transmission of emerging health care-associated pathogens: Norovirus, Clostridium difficile, and Acinetobacter species. Am J Infect control 2010;38(5 Suppl 1): S25–S33.

WHO Surgical Site infection Prevention Guidelines. Web Appendix 7. Summary of a systematic review on the effectiveness and optimal method of hair removal.

How to cite this article:

Krishnaveni, M. K., Anil Kumar Bilolikar and Sister Mariyamma Thomas. 2023. Potential Reservoirs of Nosocomial Pathogens in A Hospital: An Investigational Study. *Int.J.Curr.Microbiol.App.Sci.* 12(08): 267-274. **doi:** https://doi.org/10.20546/ijcmas.2023.1208.028