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Controlled Substance Liquid Waste Management Systems As Potential Reservoirs for Nosocomial Infection in a Pediatric Hospital

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OBJECTIVE The purpose of this study was to determine if controlled substance waste management systems (CSWMS) demonstrate microbial growth, and therefore present a potential infection risk to pediatric hospital patients.

METHODS Twenty CSWMS, either Smart Sink or Pharma Lock systems, located in patient care areas were sampled. Twelve were located in critical care areas. Cultures were obtained by swabbing the drain grate with a sterile swab. Swabs were then transported to the microbiology lab for culture. Each sample was labeled with the location of the CSWMS and each system was photographed.

RESULTS Of the CSWMS sampled, 50% demonstrated bacterial or fungal growth with a total of 15 microorganisms isolated, including 3 systems with *Micrococcus luteus,* 2 with *Aspergillus* species, and 2 with *Bacillus cereus*. Nine of the 15 microorganisms isolated were from systems in the pediatric intensive care unit (PICU) followed by 2 microorganisms in the neonatal intensive care unit (NICU). Of the 12 systems sampled in critical care areas, 8 (66%) had positive cultures. Of the 10 systems which demonstrated growth, 9 were Pharma Lock and 1 was Smart Sink.

CONCLUSION Controlled substance waste management systems harbor potential pathogens and may serve as reservoirs of infectious agents in pediatric hospitals. Microbial growth was identified in more than half of sampled CSWMS located in critical care areas, where the most vulnerable patients are located. Based on this study, a cleaning procedure for CSWMS should be implemented. Further investigation on the relationship between CSWMS and nosocomial infections is warranted.

ABBREVIATIONS CSWMS, controlled substance waste management systems; NICU, neonatal intensive care unit; PACU, post anesthesia care unit; PICU, pediatric intensive care unit; Rehab, inpatient rehabilitation unit; TICU, transitional intensive care unit

KEYWORDS drug and narcotic control; fluid waste disposal; fomites; infection control; infection; hospital; infectious disease transmission; nosocomial infection

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Introduction

Nosocomial infections are associated with increased morbidity and mortality in pediatric patients.[1–3] In addition, nosocomial infections are associated with prolonged length of hospitalization and represent a significant economic healthcare burden.[4] Both intrinsic and extrinsic factors contribute to the increased risk of developing a nosocomial infection.[5] Medical devices are a type of extrinsic factor that are potential reservoirs for infectious pathogens and have been linked to pathogen transmission.

In 2005, the Centers for Disease Control and Prevention identified *Ralstonia* colonization or infection in multiple pediatric patients being treated with oxygen humidification devices.[6] Additionally, bacterial contamination of ventilator circuits in a neonatal intensive care unit (NICU) have been linked to respiratory tract infections.[7] The risk of transmission from contaminated reservoirs is greatly reduced by stringent hand hygiene and early identification and decontamination measures.[8] Furthermore, inanimate surfaces such as pens, ice machines, and hand sanitizer dispensers are frequently used, rarely cleaned, and often colonized with potentially infectious pathogens. Cross-transmission from these surfaces poses a significant risk in patient colonization and infection. For example, hand sanitizer dispensers and the ink pens used in intensive care units have been identified as fomites colonized with opportunistic bacteria, such as coagulase-negative *Staphylococci*.[9–11] Ice and

water have also been linked to infections in both the community and hospital settings.[12,13]

Controlled substance waste management systems (CSWMS) are an example of hospital devices installed in patient care units that may not be regularly cleaned and therefore may harbor potentially pathogenic microorganisms. Controlled substances are often supplied to hospitals in unit-dose packaging to allow for storage in automated dispensing cabinets on patient care units. However, in order to administer specific weight-based doses to pediatric patients, part of the unit-dose must be wasted. Controlled substance waste management systems offer a tamper-resistant receptacle for nurses to securely dispose of excess controlled substances and prevent liquid waste from entering waterways. For convenience, CSWMS are located on patient care units in medication rooms, hallways, and patient rooms. The purpose of this project was to determine if CSWMS are reservoirs for potentially pathogenic microorganisms.

Materials and Methods

This quality control/quality improvement project was performed at a free-standing children's hospital in the United States. Twenty of the 41 (49%) CSWMS across inpatient and outpatient areas in the hospital were sampled on the same day by 2 health professionals (MM, BA) in 2019. An effort was made to sample at least 1 CSWMS on each unit. On units with multiple CSWMS, those blocked by rounding teams or in rooms with active procedures were skipped so as not to interrupt patient care. Ten CSWMS were located outside patient rooms in the pediatric intensive care unit (PICU), 2 were located near automated dispensing cabinets in the NICU, and 5 were located in various general pediatric units. The 3 remaining CSWMS were located in the post anesthesia care unit (PACU), transitional intensive care unit (TICU), and inpatient rehabilitation unit (Rehab). Two CSWMS located in the surgical unit and in the PICU were not sampled to avoid interrupting patient care. All CSWMS sampled at the institution were either Smart Sink or Pharma Lock systems made by Stryker Corporation.

Sterile specimens were collected using BBL Culture Swabs Collection and Transport Systems. The sampling process was consistent between the 2 health professionals to avoid differences in technique. Using 1 sterile swab per CSWMS, cultures were obtained by swabbing in 2 circular motions around the drain grate and into the drain grate 4 times by the same individual. Each sample was immediately placed in a sterile transport container, labeled with the location of the CSWMS, and numbered in the order of sampling. Photographs of each system were obtained at the time of sampling and labeled to correspond with the sample number. Immediately upon completion of sampling, swabs were hand-delivered to the onsite microbiology lab for culture. About 2 hours lapsed between the start of sampling and delivery of all samples to the lab. Specimens were plated on blood agar plates and MacConkey agar plates. Plates were then stored in the microbiology laboratory and monitored daily for growth for a period of 72 hours. Once all specimens were complete, the culture results were reported to the investigators. The investigators then performed a literature search to determine if the identified microorganism(s) have published evidence of causing infections in humans. An analysis of the results was performed to identify any patterns based on location, CSWMS type, or microorganism. The number of CSWMS with growth were compared with all CSWMS sampled and further categorized by location.

Results

Ten of the 20 CSWMS tested grew 1 or more microorganisms. Of the 10 CSWMS, there were 15 speciated microorganisms. Excluding duplicates, 11 different microorganisms were identified. *Micrococcus luteus* was identified in 3 different CSWMS. Both *Aspergillus* species and *Bacillus cereus* were identified in 2 different CSWMS. The remaining organisms were each isolated once: *Corynebacterium coyleae*, *Microbacterium oleivorans*, *Micrococcus hominis*, *Paenibacillus urinalis, Staphylococcus capitis*, *Staphylococcus epidermidis*, *Staphylococcus hominis*, and bacillus-like Gram-positive rods, which could not be further identified (Table).

Nine of the 15 positive cultures were from CSWMS in the PICU followed by 2 microorganisms in the NICU. Of the remaining four microorganisms, 3 were isolated in a general care unit and 1 was isolated in Rehab. Of the 12 systems sampled in critical care areas, 8 (66%) had positive cultures. Of the 10 systems which demonstrated growth, 9 were Pharma Lock and 1 was Smart Sink. Furthermore, visual inspection and growth results did not correlate, as organisms were identified in CSWMS that appeared dirty and clean. Conversely, some CSWMS that appeared dirty did not show any microbial isolates (Figure).

Discussion

This study demonstrated CSWMS can serve as reservoirs for potentially pathogenic microorganisms. To date, there are no other published studies evaluating microorganism growth on CSWMS. Fifteen speciated microorganisms were isolated from CSWMS and most of the microbial growth was present in the PICU and NICU. This is a significant concern. While nosocomial infections are a threat to all patients, certain populations are at a higher risk of morbidity and mortality. Patients are more likely to be immunocompromised and more acutely ill in critical care areas of the hospital, making them more vulnerable to potential nosocomial infections.

Seven of the 11 different microorganisms identified have been associated with previously documented

Table. Type and Frequency of Microbial Growth Across CSWMS Sampled

Species	Number of CSWMS	% Positive Results (n = 15)*	Location(s)
Aspergillus species	2	13%	PICU
Bacillus cereus	2	13%	PICU
Corynebacterium coyleae	1	7%	PICU
Microbacterium oleivorans	1	7%	NICU
Micrococcus hominis	1	7%	Gen Peds
Micrococcus luteus	3	20%	NICU, PICU, Rehab
Paenibacillus urinalis	1	7%	PICU
Staphylococcus capitis	1	7%	PICU
Staphylococcus epidermidis	1	7%	PICU
Staphylococcus hominis	1	7%	Gen Peds
Gram-positive rods, bacillus-like	1	7%	Gen Peds

CSWMS, controlled substance waste management system; Gen Peds, inpatient general pediatrics unit; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit; Rehab, inpatient rehabilitation unit

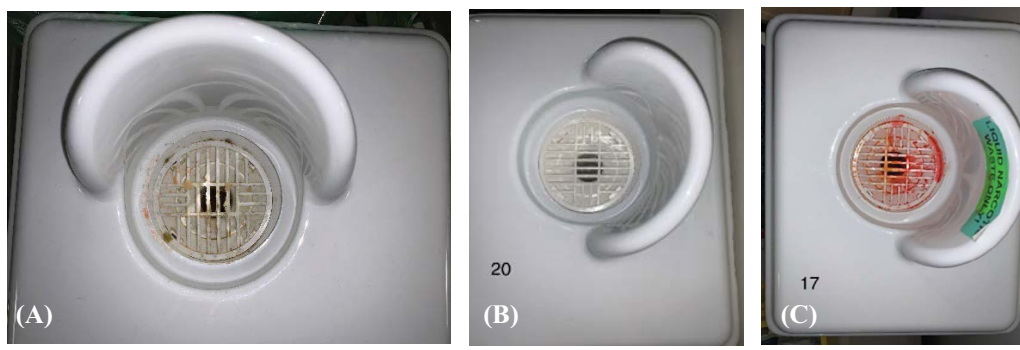
* Reported as values rounded to the nearest whole number.

infections. *Micrococcus luteus*, identified in 20% of CSWMS, is part of normal skin flora and often considered a contaminant.[14] However, severe infections, particularly brain abscesses and endocarditis, have been reported in immunocompromised patients with *M. luteus*.[14,15] *Bacillus cereus*, identified in 13% of the devices, is considered an environmental contaminant found in soil, food, and human skin.[16] *B. cereus* forms spores and biofilms and has caused local and systemic nosocomial infections in the past.[16] *Aspergillus* species were identified in 13% of the CSWMS samples. Major building construction has previously been reported to be the source of aspergillosis in immunocompromised children.[17] Most of the remaining identified microbes have caused a wide range of documented local and systemic infections, from nephritis to bacteremia.[18–23] The vast extent and variety of isolates identified within the CSWMS is alarming, especially within critical care settings. Furthermore, some of the identified bacteria have already been specifically linked to nosocomial infection.[7,16,17,22]

Some of the pathogens identified are considered normal microbial flora, such as *Staphylococcus epidermidis*. Others, such as *Aspergillus*, are commonly isolated from the environment. Due to their ubiquitous nature, it would be experimentally challenging to show that bacteria identified in CWMS were the source of contemporaneous infections in patients. This was outside the scope of this study, though given these findings, further investigation is warranted.

Nine of the 10 CSWMS that demonstrated microbial growth were Pharma Lock devices. Pharma Lock is smaller and more compact than Smart Sink, making it easier to place in tighter spaces such as an anesthesia cart.[24] Pharma Lock has a Bio-Ex antimicrobial coating.

Figure. Select Images of CSWMS (Pharma Lock) sampled. (A) *Micrococcus hominis*, *Staphylococcus hominis*, and bacillus-like gram-positive rods were isolated from this CSWMS located on a General Pediatrics inpatient unit. (B) *Micrococcus luteus* and *Microbacterium oleivorans* were isolated from this CSWMS located in the NICU. (C) No microorganisms were isolated from this CSWMS located in the PICU.



CSWMS, controlled substance waste management system; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit

The study samples were taken from the interior space of the devices which may not have the antimicrobial coating. There are no cleaning instructions for these devices. The only recommendation is the replacement of the interior container every 90 days or less.[25]

The location and quantity of the CSWMS must also be considered. More CSWMS are located in the PICU (10 of 20 tested were located in the unit) than any other unit in order to provide easy access to controlled substance disposal. In addition, more Pharma Lock than Smart Sink systems are located in the PICU because they are smaller and easier to position outside of patient rooms. Not only are there more systems in the PICU, but these are also the most frequently utilized. All of these factors contribute to an increased risk of microbial growth.

At the time of sampling, a cleaning or cartridge replacement policy did not exist for CSWMS. Pharmacy staff replaced the full or nearly full cartridge when requested by nursing staff. Medication residue, particularly thick oral liquid medication, encrusted the drain grate of several CSWMS at the time of sampling. Some CSWMS had stickers on them reminding users to only dispose of liquid medication in the device, posing an additional reservoir for bacteria (Figure C). As the results suggest, the appearance of cleanliness did not correlate with isolation of bacteria. A cleaning protocol based on cartridge replacement and surface cleaning at regular intervals would be more effective than cleaning and replacing cartridges on an as-needed basis. Regular intervals for cleaning should be 90 days or less to coincide with manufacturer cartridge exchange recommendations. Given the variety of organisms isolated, cleaning procedures should involve the use of hospital-grade disinfectant.

It was anticipated that all samples would be contaminated with bacteria present on the surface and drain grate of the CSWMS. The lack of isolation of bacterial or fungal species in 10 of the 20 CSWMS sampled does not indicate sterility, only the degree of the culture sensitivity. The isolation of bacterial species could be a measure of surveillance when investigating the effectiveness of cleaning protocols in future studies, as this would identify organisms with the highest load and therefore the highest theoretical risk of infection transmission.

This study has several limitations, including our small sample size of CSWMS in 1 children's hospital. Our findings may not be representative of other CSWMS or other institutions. Some CSWMS devices were not sampled in the hospital; this study was not comprehensive. Although 2 medical professionals were consistent in sampling or administrative roles, there may have been small variations device to device resulting in missed microbial growth that was present.

Controlled substance waste management systems are relatively new devices and neither information describing the frequency of microorganism contamination nor recommendations for cleaning and disinfecting exist. The extent and variety of microorganisms isolated in this study suggest CSWMS are reservoirs for potential nosocomial pathogens and should undergo formal risk assessments conducted by infection prevention and control programs. Findings from this study should be utilized to promote CSWMS-specific cleaning and disinfecting protocols in the future.

Conclusion

Controlled substance waste management systems harbor potential pathogens and may serve as a reservoir of infectious agents in pediatric inpatient care units. There was microbial growth present in more than 50% of sampled CSWMS located in critical care areas, where the most vulnerable patients are located. Based on this study, a cleaning procedure for CSWMS should be implemented. Further investigation on the relationship between CSWMS and nosocomial infections is warranted.

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