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Assessment of the Overall and Multi-drug Resistant Organism (MDRO) Bioburden on Environmental Surfaces in Healthcare Facilities

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REVISED ABSTRACT

Background: There is increasing need to understand the role of high-touch environmental surfaces in transmission of MDROs. Despite the likelihood that bacteria are unevenly spread over large surface areas and transmission risk is proportionate to bioburden, previous studies sampled small areas (≤100 cm²) qualitatively. Sampling large surface areas (>1000 cm²) quantitatively, we sought to establish overall and MDRO bioburden levels on high-touch surfaces in various healthcare settings after routine (RC) or terminal cleaning (TC).
Methods: From 11 inpatient healthcare facilities in 4 states, surface samples were collected from high-touch sites in MDRO isolation rooms after RC or TC using a standard sampling protocol. Two composite samples were collected from each room and a third composite was collected from *C. difficile* isolation rooms only. Composite 1 included the TV remote, telephone, call button and bedrails. Composite 2 included the room door handle, IV pole and over-bed table. Composite 3 included the bathroom (door handle, flush handle and grab bars) or toileting site (portable commode/bedpan). Samples were processed, the overall bacteria and MDROs (MRSA, VRE, *A. baumannii*, *K. pneumoniae*, and *C. difficile*) were quantified, and results from RC and TC rooms were compared. **Results:** A total of 360 composite samples were collected from 166 rooms (113 RC and 53 TC). The mean and range of overall bacteria and MDROs recovered is shown in Table 1. MDROs were recovered from 46% (77/166) of rooms; VRE was the most recovered MDRO (21%, 34/166). Higher bioburden was significantly associated with RC rooms (p<0.0001) and composite 1 (p=0.0003). A room bioburden level >1,281 CFU/100 cm² increases the risk of recovering any MDRO from the room (RR=2.02, p<0.0001).

Table 1.

Room Type	Overall Bacteria Mean CFU/100 cm² (Range)	MDRO Mean CFU/100 cm² (Range)
RC	5,373 (≤1 – 147,000)	372 (≤1 - 13,000)
TC	687 (≤1 – 7,800)	13 (≤1 – 524)

Conclusion: RC MDRO rooms, specifically surfaces close to the patient (composite 1), are more likely to have higher bioburden which may increase the risk of recovering an MDRO. In an effort to prevent transmission of MDROs from the environment it is important to assess an unsafe level of bioburden on surfaces and to determine the adequacy of cleaning methods.

BACKGROUND

- There is an increasing need to understand the role of the physical environment in healthcare facilities and how it contributes to the transmission of multi-drug resistant organisms (MDROs).
- Previous research has mostly been qualitative or has focused on the presence of a specific pathogen or overall contamination.
- In addition, different sampling methodologies and reporting units make these studies difficult to compare.
- The objectives of this project where to:
  - Evaluate contamination of the patient care environment with a standard high surface area composite sampling protocol.
  - Establish levels of contamination on high-touch non-critical environmental surfaces (e.g. bedrails, tables, equipment, bathrooms) with both MDROs and general bacterial flora.

METHODS

Sampling Plan

- Hospitals or LTCFs from four states (GA, IL, MD, and VT)
- MDRO Isolation Rooms:
  - *Acinetobacter baumannii*
  - *Clostridium difficile*
  - *Enterococcus sp.* (Specifically VRE)
  - *Klebsiella pneumoniae* (ESBL and KPC)
  - MRSA
- Composite samples (~2258 cm²) were collected from high-touch surfaces after routine or terminal cleaning of rooms

Sponge-wipe sampling method

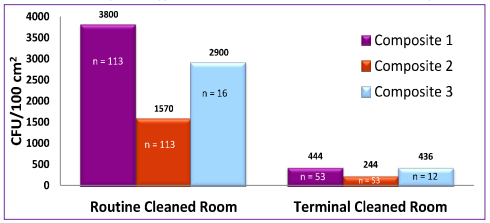
Composite 1: Bedrails, TV remote, call button, telephone

Composite 2: Over-bed table, IV pole, room door handle

Composite 3: Toileting sites *C. difficile*-isolated patients

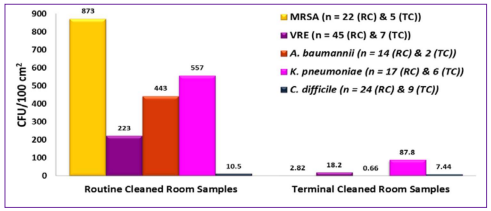
RESULTS – Composite Samples

Chart 1: Mean Microbial Bioburden (CFU/100 cm²) by Composite Type from Routine and Terminal Cleaned Samples



- The largest range was seen for Routine Composite 1 (≤ 1 - 130,000 CFU/100 cm²)
- The smallest range was seen for Terminal Composite 3 (3.5 – 2,160 CFU/100 cm²)

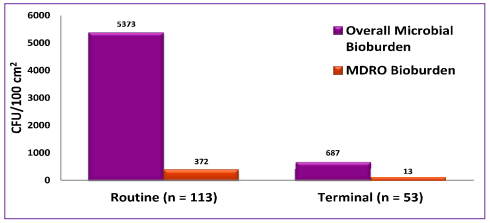
Chart 2: Mean MDRO Bioburden from Positive Routine and Terminal Cleaned Room Samples



- The largest range was for MRSA from Routine samples (≤ 1 - 13,000 CFU/100 cm²)
- The smallest range was for *A. baumannii* from Terminal samples (0.66 CFU/100 cm²)

RESULTS – Room Samples

Chart 3: Mean Room Overall Microbial and MDRO Bioburden from Routine and Terminal Cleaned Rooms (Composite 1 and 2 summed)



Ranges (CFU/100 cm²):

- Routine Overall Microbial: ≤ 1 - 147,000
- Terminal Overall Microbial: ≤ 1 – 7,800
- Routine MDRO : ≤ 1 – 13,000
- Terminal MDRO ≤ 1 - 524

Table 1: Percent Recovery of MDROs from Routine & Terminal Cleaned Rooms (n = total rooms positive)

	All MDROs	MRSA	VRE	*A. baumannii*	*K. pneumoniae*	*C. difficile*
Routine (n = 113)	52.2 (59)	12.4 (14)	25.7 (29)	9.7 (11)	11.5 (13)	16.8 (19)
Terminal (n = 53)	34.0 (18)	9.4 (5)	9.4 (5)	3.8 (2)	9.4 (5)	13.2 (7)
All Rooms (n = 166)	**46.4** (77)	11.5 (19)	**20.5** (34)	7.8 (13)	10.8 (18)	15.7 (26)

- 46% of *A. baumannii* positive rooms were multi-drug resistant (6/13)
- 22% of *K. pneumoniae* positive rooms were ESBL+ (4/18)
- 5.6% of *K. pneumoniae* positive rooms were KPC+ (1/18)

RESULTS – Modeling

Table 2: Influence of Higher Room Microbial Bioburden Counts (>1,281 CFU/100 cm²) on Recovery of MDROs (n = 154)

MDRO	RR	95% C.I.	X^2	P – value
MRSA	3.28	(1.37, 7.87)	7.07	0.0079
VRE	2.17	(1.17, 4.01)	6.06	0.0139
A. baumannii	6.37	(1.83, 22.24)	8.44	0.0037
K. pneumoniae	4.97	(1.87, 13.25)	10.28	0.0013
C. difficile	1.08	(0.51, 2.28)	0.04	0.8491
Any MDRO	**2.02**	(1.46, 2.79)	18.02	<0.0001

- A room with a microbial count > 1,281 CFU/100 cm² was significantly more likely to have any MDRO recovered.
- Recovery of *C. difficile* was not associated with higher microbial bioburden.
- Positive recovery of an MDRO from a room is decreased with use of bleach ($p = 0.0483$; RR 0.46) and increased with use of a quaternary ammonium ($p = 0.286$; RR 1.46).
- In addition, higher composite sample bioburden was significantly associated with routine cleaned rooms (p<0.0001) and composite 1 (p=0.0003).

CONCLUSIONS

- Routine cleaned MDRO rooms, specifically surfaces close to the patient (composite 1), are more likely to have higher bioburden which may increase the risk of recovering an MDRO.
- Future studies are needed to analyze HAI acquisition and association with bioburden levels >1281 CFU/100 cm². If these levels are proven to be "unsafe" then approaches to hospital room cleaning could be standardized and monitored.
- Additional work is utilizing whole genome sequencing to provide a better understanding of the hospital environmental microbiome.

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