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Frequency of *Klebsiella pneumoniae* carbapenemase (KPC) and non-KPC-producing *Klebsiella* contamination of Healthcare workers and the environment

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Abstract

We examined contamination of healthcare worker (HCW) gown and gloves after caring for patients with *Klebsiella* Producing Carbapenemase-producing and non-KPC-producing *Klebsiella* as a proxy for horizontal transmission. Contamination rate with *Klebsiella* is similar to MRSA and VRE, with 14% (31/220) of HCW-patient interactions resulting in contamination of gloves and gowns.

Background

Factors that contribute to transmission and methods to limit the spread of KPC-producing organisms are not well known.¹ Among patients with methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant Enterococcus (VRE) and multidrug-resistant *Acinetobacter baumannii* (MDR-AB), contamination of the environment and healthcare workers attire during routine care is common.² The objective of this study was to examine if there was a difference in frequency healthcare worker gown and glove contamination after caring for patients with KPC-producing and non-KPC producing *Klebsiella* as well as to examine risk factors associated with contamination.

Methods

Study location and design

This study was conducted at the University of Maryland Medical Center (UMMC), Baltimore, MD between May 26, 2009 and March 9, 2010. UMMC is a 662-bed academic

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center. Subjects were enrolled from the UMMC medical, surgical and cardiac surgery and trauma intensive care units (ICU).

Patients were identified as infected or colonized by positive clinical culture with growth of *Klebsiella* (KPC-producing or non-KPC-producing) in the preceding 14-days. Identification of *Klebsiella* spp. was performed using standard laboratory methods and susceptibility testing was performed following the Clinical Laboratory and Standards Institute (CLSI) guidelines as part of routine care.³ KPC-producing *Klebsiella*, found on HCW clothing or environmental samples, was defined as resistant to both imipenem and ertapenem or by modified hodge test positivity, all other *Klebsiella* isolates were considered non-KPC-producing *Klebsiella*.

HCWs (e.g. registered nurses, nurse practitioners, patient care technicians, respiratory therapists, occupation/physical therapists and physicians) engaging in care with the patients defined above were asked to participate in the study before entering the patient room to engage in routine patient care. All patients (those with KPC-producing and non-KPC-producing *Klebsiella*) were on Contact Precautions, either because they were in an ICU with a universal gown and glove protocol or they had a known multidrug-resistant organism (MDRO) requiring isolation according to UMMC infection control policy. HCW activities in the patient room were documented, including duration of visit and activities performed in the room. The number of times where the HCW touched one of nine environmental surfaces and number of HCW-patient interactions was counted.² On completion of patient care activities and before room exit, HCW gloves and gowns were cultured in a standardized fashion by the researchers. Environmental sampling of nine sites was performed, using a standardized method, after enrollment of up to five HCWs on the same day.² At the same institution, during the same time period, using similar sampling techniques, studies examining HCW clothing and environmental contamination with other MDROs (MRSA, VRE, MDR *A.baumannii* and multidrug-resistant *Pseudomonas*) were conducted.^{2,5}

Microbiology

For identification of *Klebsiella* (HCW clothing and environmental samples), swabs were vortexed in 5mL of brain heart infusion broth, incubated at 37° overnight, plated to MacConkey agar and incubated at 37° overnight. Lactose fermenting colonies were sub-cultured onto trypticase soy agar with 5% sheep blood (Becton Dickinson, Sparks, MD). Analytical profile index 20E test strip were used for identification of oxidase negative isolates. If unidentifiable using API 20E then Vitek II (Biomerieux, Durham, NC) was used for identification. KPC-producing *Klebsiella* were defined as resistant or intermediate to ertapenem or those with a positive Hodge test.

Statistical methods

We report frequency of HCW and environmental contamination overall and stratified by patient infection status (KPC producing vs. non-KPC producing). Confidence intervals for the proportion of contamination are Clopper-Pearson (exact) intervals. P values are from a Chi-Square test for HCW contamination and a Fisher's Exact Test for environmental contamination. We assess the association between HCW contamination and environmental

factors, patient-specific factors, and HCW type. P values are from Chi-Square or Fisher's Exact tests. All data analysis was conducted with SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

Results

We observed 220 unique HCW-patient interactions: 96 HCW interactions with KPC-producing patients (12 unique patients) and 124 HCW interactions with non-KPC-producing *Klebsiella* patients (16 unique patients). Overall 31/220 (14%, CI 0.09878, 0.1940) of HCW-patient interactions resulted in contamination of HCWs gloves or gowns that was no different between KPC and non-KPC producing *Klebsiella*, 10.4% vs. 16.9%, $p=0.17$. Overall 11/43 (26%, CI 0.1352, 0.4117) environmental samples were positive: KPC 2/19 (10.5% CI 1.3%, 33.1%), non-KPC-producing *Klebsiella* 9/24 (37.5% CI 18.85, 59.4%). See Table 1 for comparisons between KPC-producing and non-KPC producing *Klebsiella*. Given no difference in rates of transmission were observed, factors associated with contamination of healthcare workers by all types of *Klebsiella* were analyzed. On descriptive, bivariable analysis, factors associated with HCW contamination included the following patient activities: providing wound care (4/11 contacts results in contamination $p=0.05$), manipulation of catheter or drain (10/27 contacts result in contamination $p<0.001$) and caring for a patient with endotracheal tube or tracheostomy (15/43 contacts results in contamination $p<0.001$). See Table 2 for specific variables associated with transmission.

There were three patients that contaminated HCW gown, gloves and environment in 50% or more of observations. Patient 1, with a KPC-producing *Klebsiella*, contaminated HCW gown or gloves six of twelve times (50%) and seven of twelve environment sites (58%). Patient 2, with a non-KPC-producing *Klebsiella*, contaminated HCW gown or gloves eight of twelve times (67%) and seven of twelve environmental sites (58%). Patient 3, with a non-KPC-producing *Klebsiella* contaminated HCW gown or gloves four of six times (67%) and six of six environmental sites (100%). Common factors to all three included active *Klebsiella* bloodstream infection (patient 1 and 2 from a urinary source), sacral decubitus ulcers and extensive medical co-morbidities. Patient 1 also had diarrhea. Patient 1 and 2 were transferred from a long-term acute care hospital (LTACH). Only one patient was receiving antibiotics that covered the infecting bacteria.

Discussion

We found that during routine care, HCWs are frequently contaminated by *Klebsiella*, and this did not differ between patients colonized with KPC-producing and non-KPC producing organisms. Fourteen percent of healthcare workers had contamination of their gown or gloves after caring for a patient with KPC-producing or non-KPC-producing *Klebsiella*. Contamination rate with *Klebsiella* is similar to MRSA and VRE. Healthcare worker activities that were associated with increased contamination with *Klebsiella* included wound dressing, manipulation of patient catheter or drain and more frequent patient or environmental contact. Patient specific factors associated with increased HCW contamination included presence of a urinary catheter and presence of endotracheal tube or tracheostomy.

In the LTACH setting, transmission of *Klebsiella* has been reported to be related to patient burden of KPC-producing *Klebsiella* and direct HCW-patient contact, rather than the environment.⁴ Although our study was limited by a small sample size, we found that patient contact was related to transmission of all types of *Klebsiella*, and that contact with the environment as well as frequency of environmental contamination also increased contamination. Although there was no difference between KPC-producing and non-KPC producing *Klebsiella*, KPC-producing *Klebsiella* HCW contamination rates are comparable to contamination from other of multidrug-resistant organisms, including MRSA, VRE, and multidrug-resistant *Pseudomonas*, in which, HCW contamination rates of 13.8–18.5%, 8.5–13.9% and 8.2–17.4% respectively have been observed.^{2,5,6} However, MDR-*A. baumannii* has a much higher contamination rate of 32.9–28.7%, potentially reflecting differing mechanisms of transmission.^{2,5}

In conclusion, in the first study to our knowledge to examine frequency of HCW gown and glove contamination with KPC-producing *Klebsiella* during routine patient care, we found KPC-producing contaminated HCWs and the environment as frequently as non-KPC *Klebsiella* and rates were similar to that of MRSA and VRE identified from past studies using the same methodology. Factors, from this study, associated with more contamination included multiple HCW-patient and HCW-environmental contacts, active infection, decubitus ulcers, wound care and diarrhea.

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Table 1

Frequency with which *Klebsiella pneumoniae* carbapenase (KPC) producing *Klebsiella* and non-KPC producing *Klebsiella* contaminated healthcare worker gowns or gloves and the near patient environment

	Healthcare worker gown or glove contamination (%), n)	95% CI	P value*	Environmental contamination (%), n)	95% CI	P value*
KPC-producing <i>Klebsiella</i>	10.4 (10/96)	5.1%, 18.3%	0.17	10.5 (2/19)	1.3%, 33.1%	0.08
Non-KPC-producing <i>Klebsiella</i>	16.9 (21/124)	10.8%, 24.7%		37.5 (9/24)	18.8%, 59.4%	

* P values are from Two-sided Fisher's Exact for environmental samples and Chi2 for healthcare worker samples.

Table 2

Association between healthcare worker activities, patient specific factors and type of HCW and contamination of HCW gowns and gloves with KPC or non-KPC *Klebsiella* on room exit.

Variable	Frequency of contamination (#contaminations/ #opportunities)	P value
HCW activities in room		
Physical examination	13.3% (21/158)	0.59
Wound care	36.4% (4/11)	0.05
Manipulation of catheter or drain	37% (10/27)	<0.001
Vital signs	16.3% (8/49)	0.61
IV pump or tubing	20% (11/55)	0.15
Bed rail	22.8% (18/79)	0.006
Supply cart	17% (14/82)	0.33
Duration in patient room (> 5 min)	16.8% (18/107)	0.26
No. of patient contacts (>2)	25% (25/100)	<0.001
No. of environmental contacts (>2)	23.7% (23/97)	<0.001
Patient specific factors		
Urinary Catheter	17.2% (29/168)	0.012
Endotracheal tube/tracheostomy	34.9% (15/43)	<0.001
Healthcare Worker Type		
Physician / nurse practitioner	3.9% (3/78)	
Registered Nurse	16.3% (15/92)	0.001*
Other (physical, occupational, respiratory therapist, patient care technician)	26% (13/50)	

* p-value for comparison of 3 groups of healthcare workers