CONCISE COMMUNICATION

Frequency of *Klebsiella pneumoniae* Carbapenemase (KPC)–Producing and Non-KPC-Producing *Klebsiella* Species Contamination of Healthcare Workers and the Environment

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We examined contamination of healthcare worker (HCW) gown and gloves after caring for patients with *Klebsiella pneumoniae* carbapenemase (KPC)–producing and non-KPC-producing *Klebsiella* as a proxy for horizontal transmission. The rate of contamination with *Klebsiella* species is similar to that of contamination with methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococcus, with 31 (14%) of 220 of HCW-patient interactions resulting in contamination of gloves and gowns.

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Factors that contribute to transmission and methods to limit the spread of *Klebsiella pneumoniae* carbapenemase (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 worker (HCW) attire during routine care is common.[2] The objective of our study was to examine whether there was a difference in the frequency of HCW gown and glove contamination after caring for patients with KPC-producing and non-KPC-producing *Klebsiella* species as well as to examine risk factors associated with contamination.

METHODS

This study was conducted at the University of Maryland Medical Center (UMMC) in Baltimore, Maryland, between May 26, 2009, and March 9, 2010. UMMC is a 662-bed academic center. Subjects were enrolled from the UMMC medical, surgical, and cardiac surgery and trauma intensive care units (ICUs).

Patients were identified as infected or colonized if they had a positive clinical culture with growth of *Klebsiella* species (KPC-producing or non-KPC-producing strains) within the preceding 14 days. Identification of *Klebsiella* species was performed using standard laboratory methods, and susceptibility testing was performed in accordance with Clinical Laboratory and Standards Institute (CLSI) guidelines as part of routine care.[3] KPC-producing *Klebsiella* species, found on HCW clothing or environmental samples, were defined by resistance to both imipenem and ertapenem or by modified Hodge test positivity; all other *Klebsiella* isolates were considered non-KPC-producing *Klebsiella* species.

HCWs (eg, registered nurses, nurse practitioners, patient care technicians, respiratory therapists, occupational or 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* species) were under 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 that the HCW touched 1 of 9 environmental surfaces and the number of HCW-patient interactions were 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 9 sites was performed using a standardized method after enrollment of up to 5 HCWs on the same day.[2] At the same institution, during the same time period, using similar sampling techniques, studies that examined HCW clothing and environmental contamination with other MDROs (MRSA, VRE, multidrug-resistant *A. baumanii*, and multidrug-resistant *Pseudomonas* species) were conducted.[2,5]

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

We report frequency of HCW and environmental contamination overall and stratified by patient infection status (KPC-producing vs non-KPC-producing *Klebsiella* species). Confidence intervals (CIs) for the proportion of contamination are Clopper-Pearson (exact) intervals. *P* values are from a χ^2 test for HCW contamination and a Fisher 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 χ^2

or Fisher exact tests. All data analysis was conducted with SAS, version 9.2 (SAS Institute).

RESULTS

We observed 220 unique HCW-patient interactions: 96 HCW interactions with patients with KPC-producing *Klebsiella* species (12 unique patients) and 124 HCW interactions with patients with non-KPC-producing *Klebsiella* patients (16 unique patients). Overall, 31 (14%) of 220 (95% CI, 9.9%–19.4%) HCW-patient interactions resulted in contamination of HCW gloves or gowns; this did not differ between KPC and non-KPC producing *Klebsiella* species (10.4% vs 16.9%; $P = .17$. Overall, 11 (26%) of 43 (95% CI, 13.5%–41.2%) environmental samples were positive, including 2 (10.5%) of 19 KPC-producing (95% CI, 1.3%–33.1%) and 9 (37.5%) of 24 non-KPC-producing *Klebsiella* (95% CI, 18.85%–59.4%). See Table 1 for comparisons between KPC-producing and non-KPC-producing *Klebsiella* species. Given that 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 of 11 contacts resulted in contamination; $P = .05$), manipulation of catheter or drain (10 of 27 contacts resulted in contamination; $P < .001$), and caring for a patient with endotracheal tube or tracheostomy (15 of 43 contacts resulted in contamination; $P < .001$). See Table 2 for specific variables associated with transmission.

There were 3 patients who contaminated HCW gown, gloves, and environment in 50% or more of observations. Patient 1, with a KPC-producing *Klebsiella* strain, contaminated HCW gown or gloves 6 (50%) of 12 times and at 7 (58%) of 12 environment sites. Patient 2, with a non-KPC-producing *Klebsiella* strain, contaminated HCW gown or gloves 8 (67%) of 12 times and 7 (58%) of 12 environmental sites. Patient 3, with a non-KPC-producing *Klebsiella* strain, contaminated HCW gown or gloves 4 (67%) of 6 times and 6 (100%) of 6 environmental sites. Factors common to all 3 included active *Klebsiella* bloodstream infection (patients 1 and 2 from a urinary source), sacral decubitus ulcers, and extensive medical comorbidities. Patient 1 also had diarrhea. Patients 1 and 2 were transferred from a long-term acute care hospital (LTACH). Only 1 patient was receiving antibiotics that covered the infecting bacteria.

DISCUSSION

We found that, during routine care, HCWs are frequently contaminated by *Klebsiella* species, and this did not differ between patients colonized with KPC-producing organisms and those colonized with 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* species. The rate of contamination with *Klebsiella* species is similar to the rate of contamination with 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* contamination rates among HCW are comparable to contamination from other multidrug-resistant organisms, including MRSA, VRE, and multidrug-resistant *Pseudomonas* species, for 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. baumanii* is associated with 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 the frequency of HCW gown and glove contamination with KPC-producing *Klebsiella* species during routine patient care, we found KPC-producing *Klebsiella* species contami-

TABLE 1. Frequency with Which *Klebsiella pneumoniae* Carbapenase (KPC)–Producing *Klebsiella* and Non-KPC-Producing *Klebsiella* Species Contaminated Healthcare Worker Gowns or Gloves and the Near-Patient Environment

	Healthcare worker gown or glove contamination			Environmental contamination		
Pathogen	Proportion	Percentage (95% CI)	*P*	Proportion	Percentage (95% CI)	*P*
KPC-producing *Klebsiella*	10/96	10.4 (5.1–18.3)	.17	2/19	10.5 (1.3–33.1)	.08
Non-KPC-producing *Klebsiella* spcies	21/124	16.9 (10.8–24.7)		9/24	37.5 (18.8–59.4)	

NOTE. *P* values are from 2-sided Fisher exact test for environmental samples and χ^2 for healthcare worker samples. CI, confidence interval.

TABLE 2. Association between Healthcare Worker (HCW) Activities, Patient-Specific Factors, and Type of HCW and Contamination of HCW Gowns and Gloves with *Klebsiella pneumoniae* Carbapenase (KPC)–Producing *Klebsiella* and Non-KPC-Producing *Klebsiella* Species on Room Exit

Variable	Frequency of contamination, % (proportion) of opportunities	*P*
HCW activity in room		
Physical examination	13.3 (21/158)	.59
Wound care	36.4 (4/11)	.05
Manipulation of catheter or drain	37 (10/27)	<.001
Taking vital signs	16.3 (8/49)	.61
Touching intravenous pump or tubing	20 (11/55)	.15
Touching bed rail	22.8 (18/79)	.006
Touching supply cart	17 (14/82)	.33
Longer than 5-minute stay in patient room	16.8 (18/107)	.26
More than 2 patient contacts	25 (25/100)	<.001
More than 2 environmental contacts	23.7 (23/97)	<.001
Patient-specific factors		
Presence of urinary catheter	17.2 (29/168)	.012
Presence of endotracheal tube/tracheostomy	34.9 (15/43)	<.001
HCW type		
Physician/nurse practitioner	3.9 (3/78)	.001[a]
Registered nurse	16.3 (15/92)	
Other (physical, occupational, or respiratory therapist or patient care technician)	26 (13/50)	

[a] *P* value for comparison of 3 groups of HCWs.

nated HCWs and the environment as frequently as non-KPC-producing *Klebsiella* species, and we found that contamination rates were similar to rates of MRSA and VRE contamination identified from earlier studies that used the same methodology. Factors from this study that were associated with more contamination included multiple HCW-patient and HCW-environmental contacts, active infection, decubitus ulcers, wound care, and diarrhea.

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