veillance perianal and sputum sample cultures and used enrichment techniques to determine the prevalence of KPC-producing Enterobacteriaceae using identical laboratory methods and definitions for each facility. We also performed molecular typing on bacterial strains harboring KPC genes and revealed a dominant strain type for both *K. pneumoniae* and *E. coli*.

This study has several limitations. We could not rule out response bias, because only 70% of the healthcare facilities participated in survey. At the time of this study, the importance of urine as a specimen to detect CREs was unknown; therefore, we might have missed patients colonized with KPC-producing Enterobacteriaceae. In addition, this point prevalence was limited to patients receiving mechanical ventilation, who are known to have higher rates of colonization, and therefore the KPC-producing Enterobacteriaceae prevalence cannot be generalized to other patients populations.

In conclusion, this is the first study to our knowledge to examine the colonization rate of KPC-producing Enterobacteriaceae in a cohort of patients who received mechanical ventilation and resided in both acute and LTC healthcare facilities in a single state within the United States.

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## Extended Survival of Carbapenem-Resistant Enterobacteriaceae on Dry Surfaces

Carbapenem-resistant Enterobacteriacae (CRE) have emerged in the United States and elsewhere.[1,2] With the limited treatment options available for CRE infection and the associated high rate of mortality, preventing the transmission of CRE is of utmost importance.[1,2] Evidence that admission to a room previously occupied by patients with pathogens including *Acinetobacter baumannii* increases the risk of acquisition for the incoming room occupant and that improved disinfection can mitigate this increased risk provides the most compelling evi-

dence that contaminated surfaces contribute to transmission.[3-5] However, findings from 2 recent studies that admission to a room previously occupied by patients with extended-spectrum β-lactamase (ESBL)–producing Enterobacteriaceae did not increase the risk of acquisition for incoming patients suggests that the role of the environment may be less important in the transmission of Enterobacteriaceae than in the transmission of other pathogens.[5,6] Although CRE have been cultured from the environment during outbreaks,[7] we are not aware of any published data on the ability of CRE to survive on dry surfaces. Understanding the capacity of CRE to survive on dry surfaces is important for determining effective control strategies.

We evaluated the capacity of 2 strains of CRE to survive on dry surfaces over time. Isolates of *Klebsiella pneumoniae* and *Citrobacter freundii* were grown overnight at 37°C in trypticase soy broth (TSB). Sterile 10-mm stainless steel discs (Apex Laboratories) were inoculated with 20 μL of each organism suspended in either TSB (direct from overnight broth) or water (following centrifugation of the overnight broth at 2,500 rpm for 5 minutes and resuspension in an equal volume of water). All inoculated discs were allowed to air dry overnight. To determine the number of viable bacteria on the discs after drying, each disc was placed into 10 mL of sterile water and vortexed for 45 seconds. The eluted bacteria in the sterile water were then serially diluted in a 10-fold dilution series, and 10 μL of each dilution was spread onto TSA II 5% sheep blood agar (BA; Becton Dickinson). The original sterile water into which the bacteria were eluted from the disc was filtered through a sterile 0.22-μm millipore filter (Microfil S; Millipore), and the filter was placed onto the surface of a BA plate, meaning that the limit of detection was 1 colony-forming unit (cfu). BA plates were incubated at 37°C for 48 hours, and colonies were counted. Discs were cultured on days 1 (after overnight drying), 5, 12, and 19. The experiment was performed 3 times. In one of the experiments, discs were also sampled at day 40. Paired Student *t* tests were used to compare drying times.

The recovered load from the discs was 5–7 $\log_{10}$ cfu after overnight drying (day 1; Figure 1). Viable *K. pneumoniae* dried in water and TSB and *C. freundii* dried in TSB were recovered on day 19; *C. freundii* dried in water was recovered on day 12 but not day 19. Also, *K. pneumoniae* and *C. freundii* dried in TSB were recovered on day 40 (at a mean concentration of 1.6 and 2 $\log_{10}$, respectively); *K. pneumoniae* and *C. freundii* dried in water were not recovered on day 40. *K. pneumoniae* dried in TSB lost only 2 logs of viability over the 19-day testing period and approximately 4 logs over 40 days. *K. pneumoniae* dried in TSB survived significantly longer than did *K. pneumoniae* dried in water ($P < .001$); the same was true for *C. freundii* ($P < .001$). There was no significant difference in survival between *K. pneumoniae* and *C. freundii* dried in TSB ($P = .86$) or water ($P = .20$).

Studies of Enterobacteriaceae survival on surfaces indicate a range of survival times, from a few hours to several months,

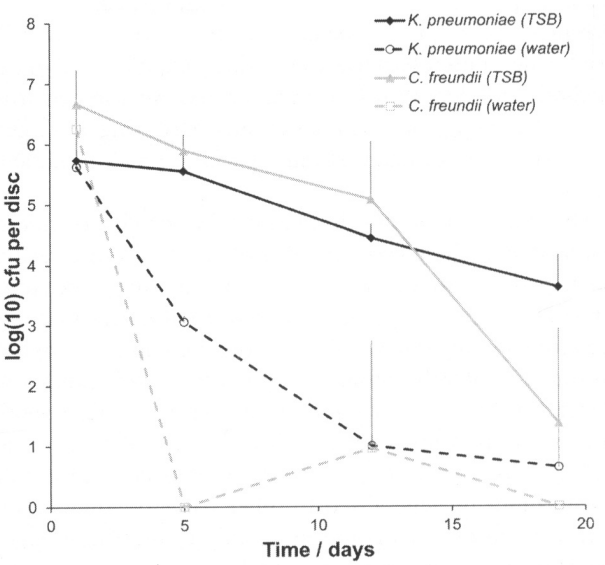


FIGURE 1. Survival of carbapenem-resistant Enterobacteriaceae dried onto metal discs. Each point represents a mean of 3 samples; error bars represent +1 standard deviation from the mean. cfu, colony-forming units.

depending on experimental conditions.[8,9] We demonstrated that highly resistant Enterobacteriaceae do not lose the capacity to survive on dry surfaces for extended periods.

Bacteria dried in TSB survived significantly longer than did bacteria dried in water, which is in line with the findings of others.[8,9] Although our findings indicate that the suspending medium is more important than species for determining survival time, we only tested 2 isolates, and other studies have identified substantial strain variation within *K. pneumoniae*.[9]

Several recent studies have identified environmental contamination with ESBL and carbapenemase-producing Enterobacteriaceae on hospital surfaces.[7,10] Resistant Enterobacteriaceae are shed into the hospital environment and have the capacity to survive on dry surfaces, which may have a role for indirect transmission,[1,4] although epidemiological studies indicate that environmental contamination with ESBL-producing Enterobacteriacae may be less important than contamination with other organisms.[5,6] However, because the major concern with CRE relates to *K. pneumoniae*,[1,2] which seems to be more closely associated with environmental contamination than are other Enterobacteriaceae,[7,10] it could be that environmental contamination is more problematic for CRE carriers than for ESBL carriers.

Because CRE are carried in the gastrointestinal tract, they could be shed at high inoculum with soiling present. Thus, we tested our strains at a high inoculum with or without soiling. Additional studies should explore the capacity of a wider range of Enterobacteriaceae to survive under varied experimental conditions in terms of inoculum, substrate, and suspending medium. Also, we did not test nonfermenters

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such as *A. baumannii*, which can also acquire carbapenemases and have the capacity to survive on dry surfaces for extended periods.[5,8,9] CRE can survive on dry surfaces for extended periods, which indicates that regular and thorough cleaning and disinfection of the patient environment and equipment should be an integral part of strategies to reduce the spread of CRE.

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## Carbapenem-Resistant Enterobacteriaceae in Pediatric Patients: Epidemiology and Risk Factors

Enterobacteriaceae with extensive antimicrobial resistance have become an important public health issue with the capacity to cause severe and life-threatening infections in vulnerable populations. Since an outbreak of carbapenem-resistant Enterobacteriaceae (CRE) species was first reported in 2003,[1] the incidence of CRE infections has increased rapidly and emerged in 36 states nationwide.[2] Risk factors for CRE infection and colonization have been well described in the adult literature.[3,4] However, description of CRE in pediatric patients has been limited to a few case reports.[5-8] Information on the epidemiology, clinical features, and risk factors associated with CRE acquisition in affected children is urgently needed.[6,7] This study characterizes a cohort of pediatric patients with positive CRE cultures, with the goal of identifying risk factors for acquisition and clinical outcomes.

This retrospective cohort study at Children's National Medical Center (CNMC) in Washington, DC, included patients who were hospitalized between August 2009 and August 2011 with 1 or more CRE organisms isolated from a clinical specimen obtained during hospitalization. The recognition of CRE was ascertained by the modified Hodge test as described by the Centers for Disease Control and Prevention.[9] During the study period, patients admitted to CNMC were not routinely screened for CRE colonization.

We also performed a case-control study to identify risk factors predisposing patients to a positive CRE culture. CRE case patients were individually matched to 4 control patients by the same age category defined by the American Association of Pediatrics. Control patients were randomly selected from those who were hospitalized at CNMC during the same time period as the case patients but who had no CRE isolated from all specimens sent for microbiologic culture testing.

The statistical analyses included descriptive analyses using $\chi 2$ test for categorical variables and Student $t$ test for continuous variables with normal distribution. Unadjusted lo-