

Development and Distribution of Educational Materials for Carbapenem-Resistant Enterobacteriaceae Among Acute and Long-term Care Facilities

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ABSTRACT

Introduction: Carbapenem-resistant Enterobacteriaceae (CRE) are multidrug-resistant organisms emerging in the United States. The Wisconsin Division of Public Health implemented mandatory hospital-based CRE surveillance starting in December 2011 and assessed educational needs of health care personnel to guide education for statewide CRE prevention.

Methods: Pre- and post-intervention electronic surveys were distributed to infection control practitioners and local health departments to determine success of educational intervention. Pre-intervention telephone interviews were conducted with infection control practitioners who reported at least 1 case of CRE.

Results: The pre-intervention survey indicated that 20 (34%) responding infection control practitioners distributed educational materials to patients or staff and 13 (57%) responding local health departments had some CRE knowledge. A pre-intervention survey and interviews identified the need for educational materials such as fact sheets, brochures, and toolkits. Five months after materials were produced and distributed, 31 (63%) responding infection control practitioners had shared educational materials with patients or staff and 11 (100%) responding local health departments indicated some CRE knowledge.

Conclusion: Overall, use of CRE educational material increased and improved general CRE knowledge among health care personnel following development and distribution of educational materials. Small sample size prevents determination of statistical significance between pre- and post-intervention responses.

BACKGROUND

Enterobacteriaceae are a group of gram-negative commensal human gut bacteria that are important causes of urinary tract infections, pneumonia, and bloodstream infections.^{1,2} Major

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species within the Enterobacteriaceae family include *Escherichia*, *Klebsiella*, and *Enterobacter*.¹

In recent years, resistance to many classes of antibiotics has emerged among Enterobacteriaceae. The most alarming recent development is the emergence of carbapenem-resistant Enterobacteriaceae (CRE). CRE are defined as Enterobacteriaceae that are nonsusceptible to doripenem, meropenem, or imipenem and are resistant to third-generation cephalosporins.²

Throughout the late 1990s, new mechanisms of carbapenem resistance emerged, predominately among *Klebsiella pneumoniae* and *Escherichia coli*, typically conferring resistance to all the β -lactam agents except aztreonam.³ These organisms produce metallo-beta lactamase enzymes such as *Klebsiella pneumoniae* carbapenemase (KPC), first reported in the United States in 1996, and New Delhi metallo-beta-lactamase (NDM-1), found predominantly in India and Pakistan.^{3,4} These metallo-beta lactam enzymes use carbapenemases to hydrolyze the beta-lactam ring of the carbapenems, leaving no option for treatment of CRE infections with beta-lactam agents.^{1,5} Whereas the AmpC beta-lactamase mechanism of resistance is chiefly chromosome-mediated, genes associated with KPC and NDM-1 production are plasmid-mediated and can be transmitted easily among species of the Enterobacteriaceae family.^{4,5}

Invasive CRE infections are associated with mortality rates of 40% to 50%, prolonged length of hospital stay, and higher health care costs when compared to infections with non-drug-resistant Enterobacteriaceae.^{1,2,4,6} Individuals most at risk of CRE acquisition include patients treated with indwelling medical devices or

antibiotics, those with underlying medical conditions, patients admitted to intensive care units, and residents of long-term care facilities.^{1,2} Currently, CRE are predominantly health care-associated pathogens, but the potential for community transmission exists.⁵ Hence, infection control and prevention efforts are crucial for reducing the risk of CRE.

In response to laboratory reports of CRE in Wisconsin, the Wisconsin Division of Public Health (DPH) initiated mandatory hospital-based CRE surveillance in December 2011.⁷ Subsequently the Wisconsin DPH began regional CRE prevention activities in the Southeastern public health region, an area identified with relatively high CRE prevalence. In 2012, CRE prevalence (number of laboratory-identified CRE events/number of admissions x 100,000) in the Southeastern public health region was 7.3, while the remainder of the state was 5.5. During the first 6 months of 2013, CRE prevalence in the Southeastern public health region was 9.1, while the remainder of the state was 2.5. Educational materials also were developed following a needs assessment to identify CRE knowledge gaps.

METHODS

Statewide hospital-based CRE surveillance was conducted using the National Healthcare Safety Network case definitions for laboratory-identified CRE events.⁷ The National Healthcare Safety Network is a Centers for Disease Control and Prevention surveillance system used for nationwide tracking of health care-associated infections. A total of 138 reporting facilities—71 Wisconsin acute care hospitals, 59 critical access hospitals, 2 children's hospitals, and 6 long-term acute care hospitals—were required to report inpatient CRE laboratory events to the Wisconsin DPH. Infection control practitioners were given CRE surveillance training via a webcast and a follow-up teleconference call prior to the December 2011 surveillance start date. A timeline of CRE education events is provided in a Table. All activities were public health-related and determined to be Institutional Review Board (IRB) exempt.

Assessments of CRE educational needs among health care personnel and local health department staff were conducted from January 2013 through October 2013 to identify potential need for CRE educational tools.⁸ In February 2013, the Wisconsin DPH e-mailed a 6-question electronic survey to infection control practitioners working at facilities that were required to report inpatient CRE laboratory events and a 4-question electronic survey to 90 local health departments. Infection control practitioners were asked to indicate their public health region, whether they had participated in collaborative groups to provide CRE infection prevention strategies across the health care continuum, whether they had educational materials on hand to provide to direct care staff and/or patients, whether they had conducted at least 1 CRE educational activity within their facilities, and to specify educational materials they desired for further education of staff and

patients. Local health departments also were asked to indicate their public health region, whether they worked with collaborative groups, and to specify educational materials they desired for further education. Additionally, local health departments were asked to indicate what knowledge they had regarding CRE risk factors, reservoirs, modes of transmission, prevention, and surveillance. All participants were instructed to complete the survey online within 2 weeks of receiving the survey.

In March 2013, telephone interviews were scheduled with infection control practitioners who had reported at least 1 case of CRE within their facility and who reported they had no educational materials available for staff or patient education. Participants were asked to identify their public health region, educational need, and barriers to interfacility communication regarding CRE status of patients and residents. Survey and interview responses were recorded. Educational materials—CRE fact sheet, educational brochure for health care personnel, and educational brochure for patients—were created and distributed to infection control practitioners and local health departments during April 2013.

Because statewide CRE surveillance identified relatively high prevalence of CRE in the Southeastern public health region and a concentration of CRE cases in Milwaukee County, the Wisconsin DPH and the City of Milwaukee Health Department convened an expert panel to develop a CRE toolkit for acute care and long-term care hospitals and for skilled nursing facilities. The panel comprised infection control personnel, communicable disease coordinators, public health nurses, hospital epidemiologists, and professional students. The toolkits incorporated the health care personnel and patient educational materials prepared in response to the survey results.

During August 2013, the City of Milwaukee Health Department hosted a CRE educational conference for hospital and skilled nursing facility staff who worked within Milwaukee County. The educational materials—previously distributed during April 2013—and the CRE toolkit were presented at this conference. Educational materials can be found here: <http://www.dhs.wisconsin.gov/communicable/ARO/CRE.htm>. Prior to the conference, participants were given a printed survey that asked them to identify whether CRE educational materials were available in their facilities for staff and patient education. Following the conference, participants were given a printed survey that asked them to evaluate whether the educational materials and toolkit were useful, whether they were easy to comprehend, and whether they would be used for further education. Participants also were asked to recommend any changes to these materials. Responses to both surveys were entered into a Microsoft Excel spreadsheet.

One month after the conference, the Wisconsin DPH e-mailed an 8-question electronic survey to the same infection control practitioners and an 8-question electronic survey to the same

Table. Timeline of Events for Carbapenem-Resistant Enterobacteriaceae (CRE) Education

Event	Timeline
CRE surveillance training via webcast and follow-up teleconference call	Prior to December 2011
Initiation of mandatory hospital-based CRE surveillance	December 2011
Assessment of CRE educational need among infection control practitioners and local health departments via electronic survey	February 2013
Telephone interviews with infection control practitioners who experienced first known cases of CRE in Wisconsin	March 2013
Creation and distribution of educational materials to infection control practitioners and local health departments	April 2013
The Wisconsin Department of Public Health and the City of Milwaukee Health Department convened expert panel for development of CRE toolkit	February 2013 – August 2013
CRE educational conference	August 2013
<ul style="list-style-type: none"> • Evaluation of educational materials and toolkit • Corrections to educational materials and redistribution 	
Assessment of CRE educational tools by infection control practitioners and local health departments via electronic survey	September 2013

local health departments. Participants were asked the same questions as the pre-intervention survey questions. Additionally, participants were asked to evaluate whether the educational materials were easy to understand and to make suggested changes to the materials. All participants were instructed to complete the survey online within 2 weeks of receiving the survey request. Responses were entered into a Microsoft Excel spreadsheet. Differences between CRE knowledge, CRE educational activities, and the availability of CRE educational tools were assessed.

RESULTS

Surveillance Data

During 2012–2013, 45 unique hospital inpatients were identified among 27 acute care facilities. Among the 45 unique hospital inpatients identified, 36 (80%) were reported from facilities in the Southeastern public health region and 25 (56%) were reported from facilities in Milwaukee County.

Pre-intervention Survey

Among 58 infection control practitioners who completed the survey, 17 (29%) reported having CRE educational materials available for staff and 15 (26%) reported having CRE educational materials available for patients within their facilities. Additionally, 20 (34%) reported that they had provided CRE educational materials to staff or patients. A total of 55 (95%) infection control practitioners indicated fact sheets and 47 (81%) indicated educational pamphlets as preferred CRE educational tools.

Among 23 local health departments that completed the survey, 13 (57%) reported having some knowledge regarding CRE. Among the 13 local health departments that reported having CRE knowledge, 9 (39%) reported knowledge about risk factors, 6 (26%) reported knowledge about reservoirs, 10 (43%) reported knowledge about modes of transmission, 10 (43%) reported knowledge about prevention measures, and 1 (6%) reported knowledge about surveillance. A total of 23 (100%)

local health departments indicated fact sheets, 14 (61%) indicated educational pamphlets, and 15 (65%) indicated surveillance data as preferred CRE educational tools.

Interviews

Four infection control practitioners—those who provided care to the first known cases of CRE in Wisconsin—were interviewed, and all identified that limited educational materials were available for educating staff and patients about CRE prevention. Each also indicated that no CRE protocols existed within their facilities prior to reporting their first case of CRE.

Pre- and Post-conference Survey

Among 36 infection control practitioners completing the pre-conference survey, 23 (64%) reported they had educational materials available for staff and 19 (53%) had educational materials available for patients. Among 35 infection control practitioners completing the post-conference survey, 34 (97%) stated that the educational tools were useful and 33 (94%) stated that the tools were easy to comprehend. Additionally, 27 (77%) reported they would use the educational tools for further CRE education.

Post-intervention Survey

Among 49 infection control practitioners completing the post-intervention survey, 37 (76%) reported they had educational materials available for staff and 31 (63%) had educational materials available for patients. Additionally, 31 (63%) reported they had provided educational materials for patients or staff. Among 18 infection control practitioners from the Southeastern public health region, 15 (83%) reported they had educational materials available for staff, 13 (72%) had educational materials available for patients, and 12 (67%) had provided educational materials for patients or staff. Among 31 infection control practitioners from the rest of Wisconsin, 22 (71%) reported they had educational materials available for staff, 18 (58%) had educational materials available for patients, and 22 (71%) had provided educational materials for patients or staff.

Among 11 local health departments completing the post-intervention survey, 11 (100%) reported some knowledge about CRE. Local health departments reported that they had increased knowledge regarding risk factors (91%, n=10), reservoirs (55%, n=6), modes of transmission (82%, n=9), prevention measures (91%, n=10), and surveillance (45%, n=5) as it relates to CRE.

Infection control practitioners and local health departments also were asked to evaluate the educational materials based on

their usefulness and comprehension. Overall, 37 (76%) of infection control practitioners responded that the educational materials were very useful or somewhat useful and 44 (90%) found them easy or somewhat easy to understand. Similarly, 8 (73%) local health departments responded that the educational materials were useful or somewhat useful and 9 (82%) found them easy or somewhat easy to understand.

DISCUSSION

Infections with CRE are a developing public health crisis in the United States and worldwide. Thus, a keen understanding of the epidemiology of CREs is critical to devising and implementing strategies for prevention. We found that in our study sample of infection control practitioners and local health departments—individuals at the frontlines of identifying and preventing CREs—self-reported knowledge regarding CRE and educational materials to facilitate understanding was largely lacking. This is an important area upon which to intervene because education of health care personnel and local health departments is a key component of CRE prevention. Although survey participation was low, we found that following the development of educational materials, most infection control practitioners reported that the materials were easy to understand, and they intended to use them in their practices. Furthermore, these materials and data collected serve as a useful starting point for further refinement in the future.

Increased availability and accessibility of CRE educational materials in the Southeastern region suggest that the intervention was well targeted among those with increased need. However, the fact that responses in the Southeastern public health region indicated increased availability and use of educational materials from those in the remaining regions may be a result of higher CRE prevalence or awareness. Practical experience with CRE cases also likely had a positive impact on CRE knowledge levels among infection control practitioners and local health departments in the Southeastern public health region.

Our study has implications for health care personnel in CRE prevention and represents an important step toward CRE prevention in Wisconsin. Incorporating pre-intervention phone interviews with front line staff directly involved in the care of patients with CRE is a strength of our study as we used those data—on type of materials available and types of materials desired—to develop our intervention. Educational materials are most likely to be used when developed in collaboration with endusers. Thus, we believe that our approach may provide a framework for other agencies and institutions developing educational materials on CRE.

Our study has a number of limitations. Determining the statistical significance of differences in pre- and post-intervention responses was not possible because of the study's small sample size. There is also the possibility of self-selection of respondents with higher CRE awareness. Additionally, the impact of the CRE edu-

cational tools on patients' knowledge of CRE was not determined, and the effect of CRE education on reducing CRE incidence was not determined. Nonetheless, a public health response to emerging health care threats must always include an educational component for health care personnel, patients, and families. Future studies should examine the impact of these strategies on CRE prevention.

CONCLUSION

Infection control practitioners reported increased access to and use of CRE educational materials following production and statewide distribution of health care personnel and patient pamphlets and fact sheets. CRE conference attendees indicated that the CRE educational materials were useful and comprehensible. Local health department staff also reported higher levels of knowledge regarding CRE following distribution of these materials.

Statewide CRE surveillance, education, and prevention continue through partnerships with the Wisconsin DPH and hospital and nursing home health care professionals. Targeted CRE prevention continues in Southeastern Wisconsin through an ongoing partnership with the City of Milwaukee Health Department. CRE collaborative activities have been expanded to other regions of the state through partnerships with the Wisconsin Chapters of the Association of Professionals in Infection Control and Epidemiology (APIC) and the Wisconsin Associations of Local Health Departments and Boards (WALHDAB).

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