

# The relationship between hospital infection surveillance and control activities and antibiotic-resistant pathogen rates

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**Background:** Antibiotic-resistant pathogen rates are rising in Canada and the United States with significant health and economic costs. The examination of the relationship of surveillance and control activities in hospitals with rates of nosocomial methicillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile*-associated diarrhea (CDAD), and vancomycin-resistant *Enterococcus* (VRE) may identify strategies for controlling this growing problem.

**Methods:** Surveys were sent to infection control programs in hospitals that participated in an earlier survey of infection control practices in Canadian acute care hospitals.

**Results:** One hundred twenty of 145 (82.8%) hospitals responded to the survey. The mean MRSA rate was 2.0 (SD 2.9) per 1000 admissions, the mean CDAD rate was 3.8 (SD 4.3), and the mean VRE rate was 0.4 (SD 1.5). Multiple stepwise regression analysis found that hospitals that reported infection rates by specific risk groups ( $r = -0.27, P < .01$ ) and that kept attendance records of infection control teaching activities ( $r = -0.23, P < .01$ ) were associated with lower MRSA rates. Multiple stepwise regression analysis found that larger hospitals ( $r = 0.25, P < .01$ ) and hospitals at which infection control committees or staff had the direct authority to close a ward or unit to further admissions because of outbreaks ( $r = 0.22, P < .05$ ) were associated with higher CDAD rates. Multiple logistic regression analysis found that larger hospitals (OR, 1.6; 95% CI, 1.2-2.0;  $P = .003$ ) and teaching hospitals (OR, 3.7 95% CI, 1.2-11.8;  $P = .02$ ) were associated with the presence of VRE. Hospitals were less likely to have VRE when infection control staff frequently contacted physicians and nurses for reports of new infections (OR, 0.5; 95% CI, 0.3-0.7;  $P = .02$ ) and there were in-service programs for updating nursing and ancillary staff on current infection control practices (OR, 0.2; 95% CI, 0.1-0.7;  $P = .01$ ).

**Conclusion:** Surveillance and control activities were associated with MRSA and CDAD rates and the presence of VRE. Surveillance and control activities might be especially beneficial in large and teaching hospitals. (Am J Infect Control 2005;33:1-5.)

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Incidence rates of methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile*-associated diarrhea (CDAD) are on the rise in Canada.<sup>1,2</sup> The United States has seen an increase in the occurrence of a number of antimicrobial-resistant bacteria, including vancomycin-resistant *Enterococcus* (VRE).<sup>3</sup> VRE is relatively uncommon in Canada, but can be reasonably expected to become an increasing problem.<sup>4</sup> Patients infected with antimicrobial-resistant bacteria have significant morbidity and mortality and incur economic costs to health care facilities.<sup>5-7</sup> Infection surveillance and control activities have been shown to be effective in reducing antibiotic-resistant pathogen rates in acute care hospitals.<sup>8</sup> We recently assessed the infection surveillance and control activities in Canadian acute care hospitals

**Table 1.** Surveillance and control activities tested by regression for association with nosocomial MRSA, CDAD, and VRE

Surveillance activities
Specific statistics collected for infections by wards, units, or service
Specific statistics collected for infections involving particular anatomical sites or medical devices
Surgical site infection rates calculated and reported to surgeons
Surgical site infection rates calculated for clean procedures
Frequency that case finding methods used to detect new cases of nosocomial infections
Hospitalized patients are examined and charts reviewed by infection control staff
Infection control staff contact physicians or nurses for reports of new infections
Infection control report forms filled out by ward staff and sent to infection control staff
Discharged patients or their physicians contacted
Charts of discharged patients reviewed by infection control staff
Computers used for tabulation of infection data and statistical software used to analyze data collected
Infection control activities
Program for teaching nursing and ancillary staff current infection control practices
Program for teaching medical staff current infection control practices
Kept attendance records of teaching activities
Monitored effectiveness of teaching activities
Communicated hospital's infection data to patient care staff
Direct authority to close wards or units to further admissions
Policy for isolation precautions for patients with <i>Clostridium difficile</i> -associated diarrhea
Policy for indications, drug choices, timing and duration of perioperative antibiotics
Complete current Health Canada Guidelines on preventing nosocomial infections

and found that only two thirds of effective surveillance activities and 60% of effective control activities were being performed.<sup>9</sup> The present study examined the relationship of surveillance and control activities in Canadian acute care hospitals with nosocomial MRSA, CDAD, and VRE.

## METHODS

### Survey

A 1-page survey was sent by fax or e-mail to the infection control programs of all 145 hospitals that had participated in our earlier survey of infection control programs in Canadian acute care hospitals for which we have extensive infection surveillance and control activity data.<sup>9</sup> Nonresponders were sent a second and third survey, and surveys were returned by fax or e-mail. The infection control programs were asked to provide the number of any and all new nosocomial cases (colonized and infected) of MRSA, CDAD, and VRE for 1999. Information from the earlier survey provided

admissions data that allowed for the calculation of infection rates.<sup>9</sup> Hospital size, surgery rates, surveillance and control index scores, and individual surveillance and control activity values were also derived from the previous survey.<sup>9</sup> The surveillance index was composed of 23 items related to the collection and dissemination of nosocomial infection and antibiotic resistance data, and the control index consisted of 44 items related to activities directed toward the reduction of nosocomial infections and patient colonization by resistant pathogens.<sup>9</sup>

### Statistical analysis

Simple regression was used to test the association of hospital size, hospital teaching status, surveillance and control index scores, and individual surveillance and control activities with MRSA and CDAD rates. The individual infection surveillance and control activity items chosen had sufficient variation in responses to test the association (Table 1). Variables found to be significant at the <.05 level were tested by multiple stepwise regression analysis with forward and backward selection for association with MRSA and CDAD rates. Separate multivariate models were developed for MRSA and CDAD. The forward selection procedure adds variables if the probability of F to enter was  $\leq .05$ , and the backward elimination procedure subtracts variables if F to remove was  $\geq .05$ .

Because only one third of hospitals reported having any VRE cases in 1999, this dependent variable was dichotomized as hospitals with and without VRE. Univariate logistic regression analysis was used to test the association of hospital size, hospital teaching status, surveillance and control index scores, and individual surveillance and control activities with the presence of VRE. Variables found to have *P* values <.05 were tested by multiple logistic regression for inclusion in the multivariate model by stepwise logistic regression using forward selection if the significance level of the logistic likelihood ratio test was <.05, with backward elimination if significance was >.05.<sup>10</sup> All statistical analyses were performed using the StatView 5 statistical package (SAS Institute, Cary, NC).

## RESULTS

One hundred twenty of 145 (82.8%) hospitals responded to the survey and contributed data: 117 hospitals reported MRSA data, 81 CDAD, and 116 VRE. Eleven hospitals reported not being able to provide resistant pathogen data because it was not collected in 1999 or changes in computer systems prevented access. The mean MRSA rate (colonized and infected)

was 2.0 (SD 2.9) per 1000 admissions, and the median was 0.8. Twenty-one hospitals reported having no MRSA cases. The mean CDAD rate (colonized and infected) was 3.8 (SD 4.3) per 1000 admissions, and the median was 2.3. Only 3 hospitals reported having no CDAD cases. The mean VRE rate (colonized and infected) was 0.4 (SD 1.5) per 1000 admissions, and the median was 0.0. Seventy-six hospitals reported no VRE cases, and 40 reported at least 1 case.

### Univariate regression analysis

The mean number of acute care beds per hospital was 291 (SD = 200), and the median was 239. All hospitals had surgical services; the mean number of overnight and day surgeries per 250 beds per year was 11,148 (SD = 5371), and the median was 10,181. Larger hospitals were associated with higher rates of MRSA ( $r = 0.22$ ,  $P = .02$ ) and CDAD ( $r = 0.31$ ,  $P = .005$ ) and the presence of any VRE (OR, 1.8; 95% CI, 1.6-2.0,  $P < .0001$ ). Teaching hospitals composed 24.2% (29 of 120) of the sample. Teaching hospitals were associated with higher rates of MRSA ( $r = 0.20$ ,  $P = .03$ ) and the presence of VRE (OR, 6.0; 95% CI, 2.4-14.8;  $P < .0001$ ).

The surveillance index had a mean of 63 (SD = 16), and the median score was 67 out of a maximum of 100. The surveillance index score was not associated with nosocomial MRSA and CDAD rates or VRE in hospitals. The control index had a mean of 61 (SD = 14), and the median score was 62 out of 100. The control index score was not associated with nosocomial MRSA and CDAD rates or VRE in hospitals.

Simple regression analysis identified 3 individual surveillance and control variables in addition to hospital size and teaching status to be associated with MRSA rates. Conducting surveillance and reporting on infection rates by specific risk groups based on anatomical sites or medical devices (eg, ventilator-associated pneumonia) ( $r = -0.24$ ,  $P = .01$ ), calculating surgical site infection rates for clean procedures ( $r = -0.19$ ,  $P = .05$ ), and keeping attendance records when teaching infection control techniques and procedures ( $r = -0.19$ ,  $P = .04$ ) were associated with lower MRSA rates.

Simple regression analysis identified 3 individual surveillance and control variables in addition to hospital size to be associated with CDAD rates. Hospitals that reported infection rates by specific risk groups ( $r = -0.23$ ,  $P = .04$ ) and that calculated surgical site infection rates and reported them to surgeons ( $r = -0.23$ ,  $P = .04$ ) had lower CDAD rates. When infection control committees or staff had the direct authority to close a ward or unit to further admissions because of an

infection control outbreak ( $r = 0.29$ ,  $P = .009$ ), this was associated with higher CDAD rates.

Univariate logistic regression analysis identified 4 individual surveillance and control variables in addition to hospital size and teaching status to be associated with the presence of VRE. VRE is less likely to be present when infection control staff frequently contact physicians or nurses for reports of new infections (OR, 0.6; 95% CI, 0.5-0.8;  $P = .0009$ ) and when infection control report forms are frequently completed by ward staff and sent to infection control (OR, 0.3; 95% CI, 0.1-0.8;  $P = .02$ ). Hospitals that had programs for teaching nursing and ancillary staff current infection control practices (OR, 0.3; 95% CI, 0.1-0.9;  $P = .03$ ) and that kept attendance records of infection control teaching activities were less likely to have VRE (OR, 0.3; 95% CI, 0.1-0.7;  $P = .008$ ).

### Multivariate regression analysis

Multiple stepwise regression analysis found 2 factors to be independently associated with MRSA rates in hospitals. Hospitals that reported infection rates by specific risk groups ( $r = -0.27$ ,  $P < .01$ ) and that kept attendance records of infection control teaching activities ( $r = -0.23$ ,  $P < .01$ ) reported lower rates of MRSA.

Multiple stepwise regression analysis found 2 factors to be independently associated with CDAD rates in hospitals. Larger hospitals were associated with higher CDAD rates ( $r = 0.25$ ,  $P < .01$ ). Higher CDAD rates were reported by hospitals at which infection control committees or staff had the direct authority to close a ward or unit to further admissions because of outbreaks ( $r = 0.22$ ,  $P < .05$ ).

Multiple logistic regression analysis found 4 factors to be independently associated with at least 1 case of VRE in hospitals. Larger hospitals (OR, = 1.6; 95% CI, 1.2-2.0;  $P = .003$ ) and teaching hospitals (OR, 3.7; 95% CI, 1.2-11.8;  $P = .02$ ) were associated with the presence of VRE. Hospitals were less likely to have VRE when infection control staff contacted physicians and nurses for reports of new infections more frequently (OR, 0.5; 95% CI, 0.3-0.7;  $P = .02$ ). Hospitals that had in-service programs for updating nursing and ancillary staff on current infection control practices were also less likely to have VRE (OR, 0.2; 95% CI, 0.1-0.7;  $P = .01$ ).

### DISCUSSION

Overall surveillance and control index scores were not associated with nosocomial MRSA and CDAD rates and the presence of nosocomial VRE in Canadian hospitals; however, hospital characteristics

and targeted surveillance and control activities had impacts on MRSA and CDAD rates and the presence of VRE. The response rate to our survey question permits generalization to acute care hospitals in Canada with more than 80 beds.

Larger hospitals and teaching hospitals were associated with higher rates of nosocomial resistant pathogens, and this has also been found in other studies.<sup>3</sup> Case-mix factors such as antibiotic exposure and length of stay are associated with higher rates of nosocomial resistant pathogens in larger hospitals; however, these data were not collected in our study.<sup>11</sup>

The Society for Healthcare Epidemiology of America guidelines for preventing the spread of resistant pathogens recommends active surveillance that is frequent and focused for patients at risk for carriage and colonization by resistant pathogens.<sup>8</sup> The multivariate analysis found that hospitals reporting on infection rates by specific risk groups based on anatomical sites or medical devices reported lower rates of MRSA and that, when infection control staff contacted physicians and nurses more frequently for reports of new infections, hospitals were less likely to have VRE. The protective effect of surveillance likely exists because of control measures taken, such as barrier precautions, isolation, and hand hygiene, to prevent further spread of identified resistant pathogens.<sup>8</sup>

An expert panel recommends the education and training of health care workers by knowledgeable infection control staff as a necessary component of hospital infection prevention and control programs.<sup>12</sup> The multivariate analysis found that lower rates of MRSA were reported when attendance records were kept of infection prevention and control teaching activities and that hospitals with programs for teaching and updating nursing and ancillary staff on current infection control practices were less likely to have VRE.

Higher rates of CDAD were associated with infection control committees or staff having the direct authority to close a ward or unit to further admissions because of an infection control outbreak. It is probable that this control policy was more likely a reaction to higher CDAD rates than a causal factor.

The MRSA and VRE rates reported by hospitals in our study are considerably lower than those reported in the United States.<sup>3</sup> The relatively low rate of resistant pathogens in Canadian hospitals limits the ability to identify relationships between the various surveillance and control activities and MRSA, CDAD, and VRE rates.

Our results suggest that further investments in infection surveillance and control would help control the growing problem of resistant pathogens in hospitals. Increasing the intensity of infection surveillance and control programs in larger and teaching hospitals would have the most effect on MRSA, CDAD, and VRE rates.

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## References

1. Simor AE, Ofner-Agostini M, Bryce E, Green K, McGeer A, Mulvey M, et al. The evolution of methicillin-resistant *Staphylococcus aureus* in Canadian hospitals: 5 years of national surveillance. *CMAJ* 2001;165: 21-6.
2. Pepin J, Valiquette L, Alany M, Villemure P, Pelletier A, Forget K, et al. *Clostridium difficile*-associated diarrhea in a region of Quebec from 1991 to 2003: a changing pattern of disease severity. *CMAJ* 2004;171: 466-72.
3. Diekema DJ, BootsMiller BJ, Vaughn TE, Woolson RF, Yankey JW, Ernst EJ, et al. Antimicrobial resistance trends and outbreak frequency in United States hospitals. *Clin Infect Dis* 2004;38:78-85.
4. Zhanel GG, Laing NM, Nichol KA, Palatnick LP, Noreddin A, Hisanga T, et al. Antibiotic activity against urinary tract infection (UTI) isolates of vancomycin-resistant enterococci (VRE): results from the 2002 North American Vancomycin Resistant Enterococci Susceptibility Study (NAVRESS). *J Antimicrob Chemother* 2003;52:382-8.
5. Jarvis WR. Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect Control Hosp Epidemiol* 1996;17:552-7.
6. Canadian Committee in Antibiotic Resistance. Antimicrobial resistance: a deadly burden no country can afford to ignore. *Can Commun Dis Rep* 2003;29:157-64.
7. Miller MA, Hyland M, Ofner-Agostini M, Gourdeau M, Ishak M. Morbidity, mortality, and healthcare burden of nosocomial *Clostridium difficile*-associated diarrhea in Canadian hospitals. *Infect Control Hosp Epidemiol* 2002;23:137-40.
8. Muto CA, Jernigan JA, Ostrowsky BE, Richet HM, Jarvis WR, Boyce JM, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and enterococcus. *Infect Control Hosp Epidemiol* 2003;24:362-86.
9. Zoutman DE, Ford BD, Bryce E, Gourdeau M, Hebert G, Henderson E, et al. The state of infection surveillance and control in Canadian acute care hospitals. *Am J Infect Control* 2003;31:266-73.
10. Hosmer DW, Lemeshow S. Applied logistic regression. Toronto: Wiley; 1989.
11. Sax H, Pittet D. Interhospital differences in nosocomial infection rates: importance of case-mix adjustment. *Arch Intern Med* 2002;162: 2437-42.
12. Scheckler WE, Brimhall D, Buck AS, Farr BM, Friedman C, Garibaldi RA, et al. Requirements for infrastructure and essential activities of infection control and epidemiology in hospitals: a consensus panel report. Society for Healthcare Epidemiology of America. *Am J Infect Control* 1998;26:47-60.

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