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Economic analysis of vancomycin-resistant enterococci at a Canadian hospital: assessing attributable cost and length of stay

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SUMMARY

Background: Competing resource demands have resulted in the de-escalation of vancomycin-resistant enterococcus (VRE) control programmes in some Canadian healthcare centres.

Aim: To determine the attributable costs and length of stay (LOS) of VRE colonizations/infections in an acute care hospital in Canada.

Methods: Surveillance and financial hospital-based databases were used to conduct analyses with cases and controls from fiscal year 2008–2009 (1 April 2008 to 31 March 2009) at an acute care hospital in downtown Vancouver, Canada. A statistical analysis of attributable costs and LOS was conducted using a generalized linear model. In a secondary analysis, differences in costs and LOS were examined for VRE infections versus colonizations.

Findings: A total of 217 patients with VRE and a random sample of 1075 patients without VRE were examined. VRE has a positive and significant impact on patient hospitalization costs and LOS. Overall, the presence of VRE increased the estimated mean cost per patient by 61.9% (95% confidence interval: 42.3–84.3) in relative terms and $17,949 (13,949–21,464) in absolute Canadian dollars. For LOS, the attributable number of days associated with a VRE case mean was 68.0% (41.9–98.9) higher in relative terms and 13.8 days (10.0–16.9) in absolute days. In the secondary analysis comparing VRE infection and colonization costs, no statistically significant difference was found.

Conclusions: Based on this analysis, the attributable cost and LOS of VRE are considerable. These factors should be considered before de-escalation of a hospital VRE control programme.

Introduction

Healthcare-associated infections (HCAIs) can have significant negative health impacts; moreover, their treatment,

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management, and prevention carry a substantial and growing financial burden. In the USA, there are reports describing the attributable costs of vancomycin-resistant enterococcus (VRE) in hospitals.[1–11] Sample sizes of these studies tend to be quite small, ranging from 12 to 277 VRE cases.[1–11] The increased economic costs of HCAIs are largely due to the patient's increased length of stay (LOS), and findings reveal that VRE increases the average LOS of individuals, with estimates ranging from 2.6 to 25.7 days.[1–11] The attributable cost estimates themselves are highly variable, ranging from $4,207 to $154,250 (US dollars, 2008 values), and are likely due to differences in the settings investigated, in the treatment options available at the time, and in study design including sample sizes and analysis techniques employed.[1–11] However, each study consistently reported an increased cost and LOS for patients with VRE compared with either vancomycin-susceptible enterococcus patients or uninfected patients.

In Canada, about 220,000 individuals – one out of nine patients admitted to hospital each year – acquire infections during their hospital stay.[12] It has been estimated that these infections are responsible for more than 8000 deaths each year in Canadian hospitals.[12] However, the attributable costs and LOS of VRE have not been reported in Canada.

Recently, some hospitals in Canada have opted to discontinue efforts in preventing and controlling VRE transmission. The value of VRE control programmes relative to other hospital infection prevention strategies is unknown. In this study, we examined the attributable costs and LOS of VRE colonizations/infections at an urban hospital in a Canadian setting using statistical modelling.

Methods

Data source and sample selection

The study population included patients admitted to St Paul's Hospital (Providence Health Care), an urban hospital in Vancouver, Canada, in the fiscal year 2008–2009 (1 April 2008 to 31 March 2009). All VRE patients were laboratory-confirmed cases with VRE colonization or infection ($N = 219$) from a database maintained by Infection Prevention and Control (IPAC). Controls were derived from a random sample of total patients admitted to St Paul's Hospital ($N = 18,293$ after excluding our VRE cases) from a database maintained by the Finance Department at Providence Health Care. We applied a random number generator equation to our list of all patients admitted to SPH during fiscal year 2008–2009 to select our controls; we selected about six times ($N = 1166$) the number of VRE cases. All cost information was obtained from the Finance Department and data were linked based on unique patient encounter numbers. From this initial sample, the following patient groups were excluded from the analysis: pregnant patients (89 non-VRE patients), patients aged <18 years (two VRE patients), patients with zero cost (one non-VRE patient), and patients with unknown sex classification (one non-VRE patient). After these exclusions, the dataset contained 1292 patients, consisting of 1075 controls (non-VRE) and 217 cases (patients with VRE). This work was considered an aspect of patient safety and therefore was exempt from ethics approval, but acknowledged according to the Providence Health Care/University of British Columbia Research Ethics Board.

Outcomes and variables of interest

Variables considered in our analysis were based on those previously described in the published literature and those available in our IPAC and Finance databases. We examined patient characteristics stratified by the presence or absence of VRE colonization/infection.

For all categorical variables, a Pearson chi-square statistic was computed to investigate the hypothesis of no association between the presence of VRE and the variable being tested. Fisher's exact test was computed when the expected cell count was five or fewer. A small *P*-value rejects this hypothesis. For continuous variables, a *t*-test was performed for the difference in sample means between those with VRE and those without.

We examined patient characteristics stratified by the presence or absence of VRE. Variables of interest in this analysis included: age (18–64, 65–75, and ≥75 years), sex (male vs female), in-hospital death (yes vs no), operative room visit (yes vs no), intensive care unit (ICU) admission (yes vs no) and HIV positivity (yes vs no), *International Classification of Diseases*, 10th revision (ICD-10) codes (total number of codes per patient), cost (total cost in dollars per patient), case mix group (CMG) classification (yes vs no), and major clinical category (MCC) classification (yes vs no).

There were two outcomes in this analysis. The primary outcome was attributable cost of VRE, represented by both a relative (percentage) and absolute (Canadian dollar) value. The secondary outcome was attributable LOS.

Statistical analysis

The goal of an attributable cost analysis relating to an infection is to determine patient costs had the infection (or colonization in this case) never occurred. In this study, the approach to comparative attribution was to use statistical methods in order to model the relationship between cost and HCAI status, while simultaneously controlling for other variables affecting patient costs. Using this approach, all infected and uninfected individuals could be included in the analysis.[13]

We used a generalized linear modelling (GLM) approach to conduct our regression analyses, which required specifying the distribution of cost (the family) and the relationship between cost and the explanatory variables (link function).[14,15] The choice to use a GLM over alternative modelling approaches, such as ordinary least squares, was based on best practices in the literature, and early exploratory data analysis suggesting that the cost variable is highly skewed. A log link was chosen as this has been found to best specify the relationship between cost and the explanatory variables, and is the most commonly used link function in the literature.[11,13,15] Exploratory data analysis revealed the presence of heteroscedasticity in our data through a Bruce–Pagan test. The modified Park test was conducted to determine the distribution family, and it was concluded that a gamma distribution best fit the cost data.[13] A gamma distribution implies that the variance is proportional to the square of the mean. A GLM may suffer precision losses if the residuals of the model exhibit a high kurtosis (>3 on the log scale) and in this case other regression models (i.e. log ordinary least squares) may be more appropriate. We tested for this criterion using the residuals and concluded that a GLM should indeed be used.

In terms of variable selection, we initially included all variables available in the model, and a backward selection process