CONCISE COMMUNICATION

A Successful Vancomycin-Resistant Enterococci Reduction Bundle at a Singapore Hospital

Dale Fisher, FRACP;[1,2] Long Pang, BSc(Hons);[3] Sharon Salmon, MPH;[4] Raymond T.P. Lin, FRCPA;[1,5] Cathrine Teo, BSc Nursing;[4] Paul Tambyah, MD;[1,2] Roland Jureen, MD;[5] Alex R. Cook, PhD;[3] Jonathan A. Otter, PhD, FRCPath[6]

Abstract We report a reduction in the vancomycin-resistant enterococci (VRE) rate from a peak of 1.5 cases per 1,000 admissions (95% confidence interval [CI], 1.0 – 2.1) in August 2012 to 0.5 per 1,000 admissions (95% CI: 0.3 – 1.0) by January 2015, associated with a bundle of interventions.

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Vancomycin-resistant enterococci (VRE) are common in some parts of the world, including South East Asia.[1,2] Reductions in VRE prevalence have been achieved through a number of different measures.[1,3,4] Active surveillance combined with contact precautions remains a common approach shown to reduce transmission.[1,5] Contaminated surfaces play an important role in the transmission of VRE; most prevention and control strategies include measures to decontaminate the environment.[4,6]

VRE emerged at our hospital in the mid-2000s and the VRE rate continued to increase despite implementation of targeted active surveillance in 2006. We report the impact of a VRE control bundle directed toward improving screening and isolation of VRE carriers and improving environmental hygiene.

METHODS

The VRE bundle comprised several elements designed to improve the identification and isolation of VRE carriers: (1) an expansion of active surveillance, (2) enhanced precautions signage, and (3) an automated system to identify known VRE carriers on admission. Improvements in environmental hygiene in this bundle included (1) implementation of hydrogen peroxide vapor (HPV, Bioquell, from 30% hydrogen peroxide) for terminal disinfection following the discharge of VRE patients, (2) a change in the bleach cleaning solution, and (3) an audit of general discharge cleaning using fluorescent markers. In addition, education and feedback regarding multidrug-resistant organism rates were provided regularly.

Fluorescent markers were applied to 8 high-touch objects in rooms before standard discharge cleaning, and UV light was used to inspect rooms after cleaning to ascertain adequate removal. In total, 19 rooms were evaluated pre-intervention and 23 rooms were evaluated post-intervention by comparing the rate of fluorescent marker removal. The rates of VRE-positive admission screens before and after the breakpoint were compared. The impact of the automated electronic alert system to identify known VRE carriers on admission was evaluated by comparing the proportion of known VRE carriers incorrectly admitted to an open bay rather than a side room. Fisher's exact tests were used to compare rates.

A "breakpoint" regression model was fitted to the monthly number of VRE cases per 1,000 admissions from January 2008 to January 2015. The model evaluates potentially differing trends before and after a breakpoint that is estimated by the model rather than specified a priori. Slopes around the breakpoint, mean monthly VRE incidence at the time of the change, and variability around the mean were also analyzed. We used a Markov Chain Monte Carlo routine to estimate parameters, assigning noninformative uniform prior distributions for parameters over their support within a Bayesian analysis.[7] We performed 10,000,000 iterations, retaining every 100th iteration for sampling from the posterior distribution. Samples were exported to CODA for analysis, including assessing the support for the breakpoint coinciding with the different stages of the intervention. Convergence was assessed visually. The R statistical environment was used for the breakpoint analysis (v 3.0.1).[8]

PCR was used to detect *van*A or *van*B.[9] Enterococci were identified as *E. faecium* or *E. faecalis* by PCR or MALDI-TOF mass spectrometry (Bruker Daltonik, Bremen, Germany).[9] Available isolates were typed using multilocus variable number of tandem repeats analysis (MLVA).[10]

RESULTS

A total of 405 cases were reported over this 85-month period. The peak VRE rate was 1.5 per 1,000 admissions (95% confidence interval [CI], 1.0 – 2.1) in August 2012, which decreased to 0.5 per 1,000 admissions (95% CI, 0.3 – 1.0) by January 2015. The best estimate for the breakpoint corresponds to early August 2012 (95% CI, January 2012–March 2013), when the bundle was implemented (Figure 1). The interval spans the introduction of all elements of the bundle (apart from the change in bleach and the automatic alert); thus, any or a combination of bundle elements could have played a role in the reduction of VRE.

The proportion of fluorescent markers removed by discharge cleaning improved from 60.5% (92 of 152) pre-intervention to 78.8% (145 of 184) post-intervention (odds ratio [OR], 2.4; 95% CI, 1.5 – 4.0; $P < .001$). The rate of VRE admission screening increased from 4.6 to 6.3 per 100 admissions (OR, 1.4; 95% CI, 1.4 – 1.5; $P < .001$). The proportion of known VRE carriers admitted to an open bay rather than a single room fell from 4.3% (31 of 724) to 0.6% (3 of 505) following the

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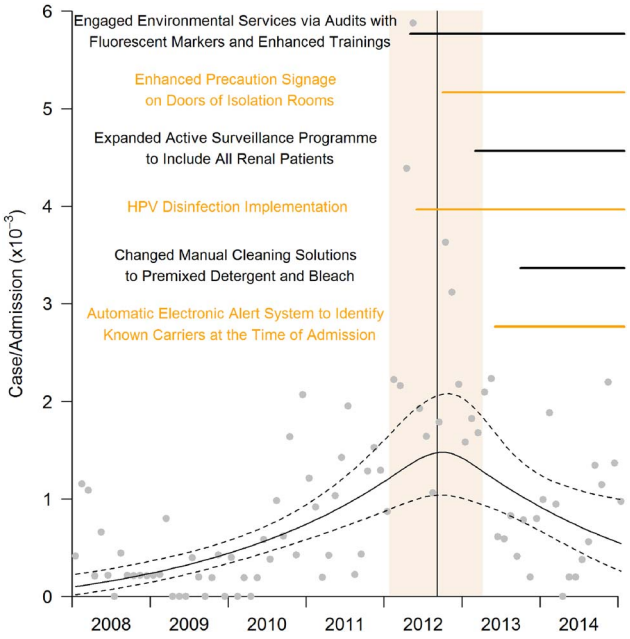


FIGURE 1. Rate of new VRE cases of infection or colonization per 1,000 admissions. The breakpoint in rate in August 2012 corresponds to the implementation a bundle of interventions.

introduction of an automated electronic alert (OR, 0.1; 95% CI, 0.03 – 0.5; $P < .001$).

Only 6% of cases occurred within the first 48 hours of hospitalization (67% of cases occurred after 48 hours of hospitalization, and 27% of cases had evidence of previous hospital admission) suggesting in-hospital transmission. The rate of cases identified in the first 48 hours of admission did not change significantly before or after of the breakpoint in August 2012 (0.3 cases per 1,000 admissions before August 2012 vs 0.4 per 1,000 admissions after August 2012, $P = .647$). A total of 63% of cases were from active surveillance cultures, 22% were from contact tracing, and 15% were clinical cultures. A total of 3,652 rooms were decontaminated using HPV since it was implemented; cycle times were approximately 2.5 hours with an additional 0.5 hours for pre-cleaning prior to HPV.

Of 395 speciated cases, 390 were *E. faecium* and 5 were *E. faecalis*. Of 279 isolates available for PCR analysis, 77% carried *van*B and 23% carried *van*A. Of 264 typed isolates, a major clone accounted for 77% of isolates and secondary clone accounted for 20% of the isolates.

DISCUSSION

Our hospital experienced a progressive increase in VRE from 2008 despite standard infection prevention and control measures. The bundle of interventions was associated with a significant change in the VRE incidence. Because the adoption of all but 2 of the interventions (change in bleach cleaning solution and electronic alert system) were included in the 95% confidence intervals around the breakpoint, we were not able to determine which intervention was responsible for the reduction, and it is plausible that >1 intervention element contributed to the result.

Implementing or improving the identification and isolation of VRE carriers through contact precautions has been shown to reduce VRE transmission in some but not all studies.[1] Some argue that VRE screening and isolation should be scaled down or even abandoned;[1,5] however, we believe that VRE screening and isolation were an integral part of the successful bundle.

Other interventions in our bundle were directed toward reducing the environmental burden of VRE, which has been shown to shed into the hospital environment and to survive on dry surfaces, and prior room occupancy by a patient with VRE has been shown to be a risk factor for VRE acquisition in the incoming room occupant.[4,6] Furthermore, improving the efficacy of discharge disinfection either by introducing HPV or by enhanced standard methods has been shown to reduce VRE transmission.[3,4] We implemented fluorescent marking to audit the quality of our conventional discharge cleaning. As in other studies, the removal of the fluorescent markers during the baseline audit period was poor (~60%).[11] We demonstrated significant improvements by feeding back audit data and educating environmental services staff. The effectiveness of HPV use has been shown in other studies.[3,6] The introduction of fluorescent markers and HPV spanned the 95% confidence interval around the breakpoint; thus it is plausible that both contributed to the reduction in VRE.

The vast majority of VRE in our study was *E. faecium* and *vanB* was considerably more common than *vanA*. MLVA identified a major clone of VRE, accounting for almost 80% of the isolations, which mapped to ST203, as reported in outbreaks elsewhere.[12]

Our study has a number of important strengths. The breakpoint model evaluated the change in VRE rate, which is less prone to bias because the breakpoint was not specified a priori. We had a detailed dataset spanning 6 years, which combined clinical and molecular data. We also collected quantitative data to verify the effectiveness of several elements of the bundle.

However, this study did not have a control group, so we cannot exclude the possibility that the reductions occurred by chance; the change in rate of VRE correlated so closely with the implementation of our bundle that this is very unlikely. Whether the increases in VRE were due to an ongoing outbreak or increasing endemic prevalence, however, remains unclear.

The finding that most VRE were identified after the first 48 hours of hospital admission in the absence of previous hospitalization, combined with the fact that 80% of the VRE isolates were from a single clone, suggests the in-hospital transmission of VRE since it emerged in 2008. Prompt identification, isolation, and management of the patients and their clinical environment led to substantial and sustained reductions in VRE.

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Affiliations: 1. Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore; 2. Division of Infectious Diseases, University Medicine Cluster, National University Health System, Singapore, Singapore; 3. Saw Swee Hock School of Public Health, National University of Singapore and National University Health System, Singapore, Singapore; 4. Department of Nursing Administration, National University Health System, Singapore, Singapore; 5. Department of Laboratory Medicine, National University Health System, Singapore, Singapore; 6. Imperial College Healthcare NHS Trust, London, UK.

Address correspondence to Professor Dale Fisher, NUHS Tower Block, 1E Kent Ridge Road, Level 10, Singapore, Singapore 119228 (mdcfda@nus.edu.sg).

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REFERENCES

1. Humphreys H. Controlling the spread of vancomycin-resistant enterococci. Is active screening worthwhile? *J Hosp Infect* 2014;88:191–198.
2. Cai Y, Chan JP, Fisher DA, et al. Vancomycin-resistant enterococci in singaporean hospitals: 5-year results of a multi-centre surveillance programme. *Ann Acad Med Singapore* 2012;41:77–81.
3. Passaretti CL, Otter JA, Reich NG, et al. An evaluation of environmental decontamination with hydrogen peroxide vapor for reducing the risk of patient acquisition of multidrug-resistant organisms. *Clin Infect Dis* 2013;56:27–35.
4. Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DA, Weinstein RA. Reduction in acquisition of vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures. *Clin Infect Dis* 2006;42:1552–1560.
5. Diekema DJ, Edmond MB. Look before you leap: active surveillance for multidrug-resistant organisms. *Clin Infect Dis* 2007;44:1101–1107.
6. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hosp Epidemiol* 2011;32:687–699.
7. Gelman A, Shalizi CR. Philosophy and the practice of Bayesian statistics. *Br J Math Stat Psychol* 2013;66:8–38.
8. R development core team. R: A language and environment for statistical computing. Vienna, Austria: R foundation for statistical computing. R Project Web site. http://www.R-project.Org. Published 2010. Accessed September 2015.
9. Dutka-Malen S, Evers S, Courvalin P. Detection of glycopeptide resistance genotypes and identification to the species level of clinically relevant enterococci by pcr. *J Clin Microbiol* 1995;33:24–27.
10. Top J, Schouls LM, Bonten MJ, Willems RJ. Multiple-locus variable-number tandem repeat analysis, a novel typing scheme to study the genetic relatedness and epidemiology of *Enterococcus faecium* isolates. *J Clin Microbiol* 2004;42:4503–4511.
11. Carling PC, Parry MM, Rupp ME, Po JL, Dick B, Von Beheren S. Improving cleaning of the environment surrounding patients in 36 acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29:1035–1041.
12. Johnson PD, Ballard SA, Grabsch EA, et al. A sustained hospital outbreak of vancomycin-resistant *Enterococcus faecium* bacteremia due to emergence of vanb e. Faecium sequence type 203. *J Infect Dis* 2010;202:1278–1286.

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