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Brief Report

Effects of environmental disinfection on the isolation of vancomycin-resistant *Enterococcus* after a hospital-associated outbreak of Middle East respiratory syndrome

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Environmental disinfection with sodium hypochlorite and hydrogen peroxide vapor was performed after a hospital-associated outbreak of Middle East respiratory syndrome. Although only 11% of total beds were disinfected, the isolation and vancomycin-resistance rates of *Enterococcus* spp significantly decreased for 2 months, whereas other multidrug-resistant organisms did not.

Environmental disinfection using sodium hypochlorite or hydrogen peroxide vapor has demonstrated its effect on reducing multidrug-resistant organisms (MDROs) in several studies, especially for high-risk wards or outbreak control.[1-4] However, because such disinfection processes require evacuation of patient rooms, the effects of environmental disinfection not targeted for MDRO-contaminated spaces have not yet been evaluated. After a hospital-associated outbreak of Middle East respiratory syndrome (MERS), we conducted environmental disinfection of patient rooms where confirmed patients with MERS stayed.[5] Although a small proportion of rooms were cleaned regardless of MDRO risks, we observed a decrease in the number of MDROs detected after the MERS outbreak. For a precise analysis, we evaluated disinfection records and microbiologic data together with inpatient numbers.

METHODS

There was a large hospital-associated MERS outbreak in South Korea from May to July 2015, and environmental disinfection was emphasized after the end of the outbreak.[5] Patient rooms where confirmed patients with MERS stayed were cleaned with sodium hypochlorite (500 ppm) 6 times after discharge. Low-level disinfectants including sodium hypochlorite, alcohol, and quaternary ammonium compounds are effective for MERS coronavirus.[6] After the cleaning process, rooms were disinfected by hydrogen peroxide vapor as previously described.[3,6,7] As 45 patients with MERS changed rooms and used 2- or 6-bed rooms as private,[5,8] a total of 86 rooms with 214 beds were disinfected, which represented 11.0% of the total 1,941 beds.

We retrospectively collected disinfection records, the number of inpatients in person-days (PD), the use of antibiotics as daily defined dose per 10^3 PD,[9] and microbiologic data from January to December 2015. Considering that the decrease of MDROs was observed for only 2 months after the MERS outbreak, this period (August to September 2015) was defined as the "post-outbreak period." The MERS outbreak period (June to July 2015) and the post-outbreak period were compared with the non-outbreak period (the rest of 2015). MRDOs included methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), third-generation cephalosporin-resistant Enterobacteriaceae, carbapenem-resistant Enterobacteriaceae (CRE), carbapenem-resistant *Pseudomonas* (CRP), and carbapenem-resistant *Acinetobacter*. *Clostridium difficile* was not included because of limited cases in our center. The Student t test was used for statistical comparison using IBM SPSS Statistics version 20.0 (IBM, Armonk, NY). All *P* values were 2-tailed and *P* <.05 was considered statistically significant.

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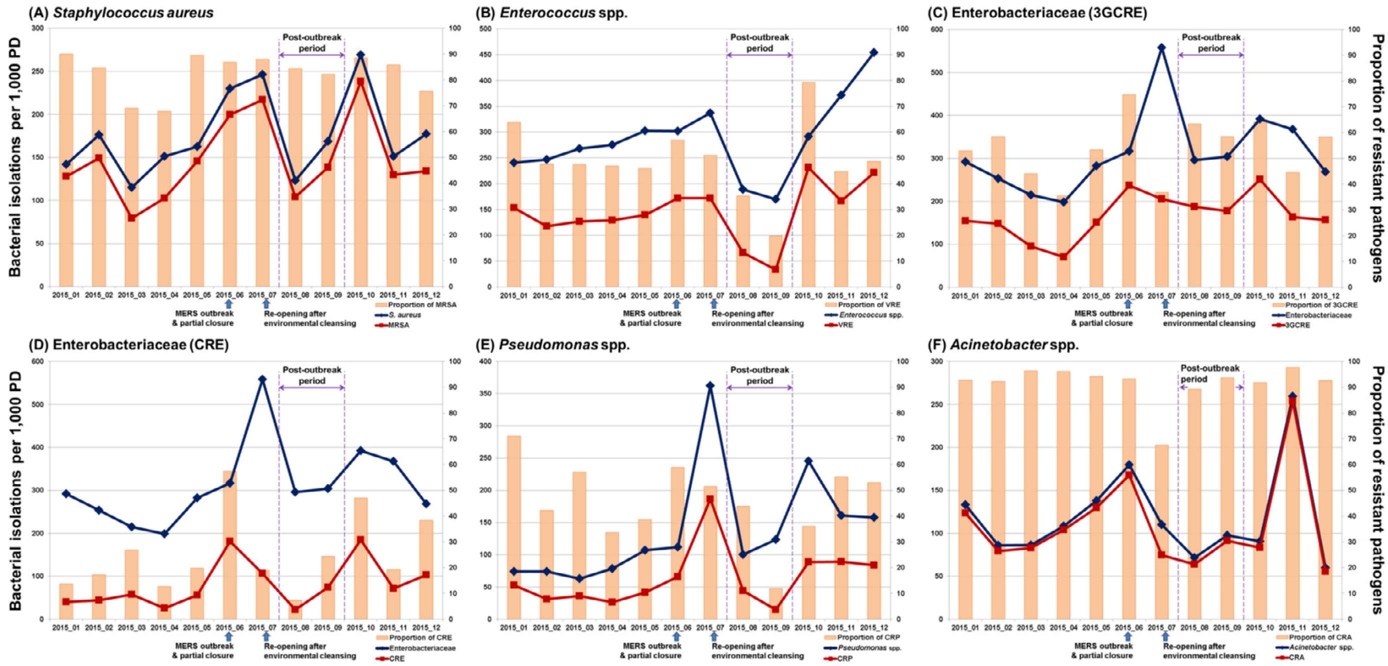

Fig 1. Overall trends for MDRO isolations at a tertiary care hospital where a MERS outbreak occurred, presented as isolations per 10^3 PD. Among the MDROs, only *Enterococcus* spp and VRE decreased significantly during the post-outbreak period (both $P < .05$). (A) *Staphylococcus aureus* and MRSA. (B) *Enterococcus* spp and VRE. (C) Enterobacteriaceae and 3GCRE. (D) Enterobacteriaceae and CRE. (E) *Pseudomonas* spp and CRE. (F) *Acinetobacter* spp and CRA. *3GCRE*, third-generation cephalosporin-resistant Enterobacteriaceae; *CRA*, carbapenem-resistant *Acinetobacter*; *CRE*, carbapenem-resistant Enterobacteriaceae; *CRP*, carbapenem-resistant *Pseudomonas*; *MDRO*, multidrug-resistant organism; *MERS*, Middle East respiratory syndrome; *MRSA*, methicillin-resistant *S aureus*; *PD*, person-days; *VRE*, vancomycin-resistant *Enterococcus*.

RESULTS

The number of inpatients dramatically dropped during the MERS outbreak period and was significantly lower than the non-outbreak period (20,790 vs 51,510 PD per month; $P < .001$). The antibiotic use per inpatient increased during the outbreak period. After the outbreak, inpatient numbers recovered rapidly from August 2015, and the number of inpatients and antibiotic prescriptions were not different between the post-outbreak and non-outbreak periods. Overall trends of pathogen isolations and MDRO proportions are presented in Figure 1, and comparisons between each period are presented in Supplementary Table S1.

Isolations of *S aureus* and MRSA decreased during the post-outbreak period, but it was not statistically significant compared with the non-outbreak period. Isolations of both *Enterococcus* spp (179.34 vs 306.26 per 10^3 PD; $P = .045$) and VRE (50.09 vs 160.60 per 10^3 PD; $P = .010$) significantly decreased during the post-outbreak period. The proportion of VRE among total *Enterococcus* spp isolates also significantly decreased (27.52 vs 53.06%; $P = .028$). These significant reductions were associated with disinfected wards/intensive care units (ICUs) (97.80 vs 202.81 per 10^3 PD; $P = .025$ for *Enterococcus* spp; 30.13 vs 85.24 per 10^3 PD; $P = .047$ for VRE). Isolations of Enterobacteriaceae, third-generation cephalosporin-resistant Enterobacteriaceae, and CRE did not decrease during the post-outbreak period. Decreased isolations of *Pseudomonas* spp and CRP decreased during the post-outbreak period were observed without statistical significance. Isolations of *Acinetobacter* spp and carbapenem-resistant *Acinetobacter* did not decrease during the post-outbreak period.

DISCUSSION

After the end of the MERS outbreak, we noticed a numerical reduction in MRSA, VRE, CRE, and CRP. Reduction of these MDROs would be influenced by 2 major factors: a decreased number of inpatients during the outbreak and environmental disinfection at the end of the outbreak. To assess the effects of environmental cleaning, we adjusted MDRO isolations with inpatient numbers and performed subgroup analysis according to the disinfection status. As a result, only *Enterococcus* spp and VRE showed statistically significant reductions and associations with environmental disinfection. Handwashing might temporally increase during the MERS outbreak and contribute to the reduction of VRE, but the significant decrease in cleaned wards and ICUs supports the effect of environmental cleaning. Considering that decreases in other MDROs were not associated with disinfected wards and ICUs, they may be more affected by a decreased admission of patients who may harbor MDROs rather than by the environmental cleaning itself. A decreased number of inpatients is likely to be associated with a reduced risk of MDRO isolation, and rapid recovery of MDRO detections within 2 months from the outbreak might reflect inflow from the outside. The overall use of antibiotics, another major factor that may affect MDRO acquisition,[10] increased during the outbreak period, suggesting it might offset the reduction of MDROs.

Of note, disinfection at the end of the MERS outbreak was performed nonselectively for MDROs, and cleaning merely 11% of the hospital resulted in the reduction of overall VRE. Previous studies evaluating environmental disinfection were designed to decontaminate rooms of patients known to be infected or colonized with MDROs.[2-4] By evaluating a post-MERS outbreak environmental disinfection, we suggest that nontargeted, partial environmental disinfection also results in reduction of overall VRE burden. This finding supports implementation of environmental cleaning measures as a routine practice, especially in hematology or transplant wards where VRE would cause clinical infections.

As a retrospective analysis, it was difficult to differentiate the effects of sodium hypochlorite cleaning and hydrogen peroxide vapor. Also, because we evaluated microbiologic data without review of medical records, we could not differentiate in-hospital acquisitions specifically. Assuming MDRO carriage rates of admitting patients did not significantly change during the study period, we supposed in-hospital acquisition of VRE decreased during the post-outbreak period.

CONCLUSIONS

Although only 11% of total beds were disinfected after a MERS outbreak, the isolation and vancomycin-resistance rates of *Enterococcus* spp significantly decreased but the effects persisted briefly for 2 months.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2019.05.032.

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