Abstract

IMPORTANCE Although contact isolation has been widely recommended for multidrug-resistant organisms, contact isolation has raised some concerns that it may bring unintended patient harms.

OBJECTIVE To compare adverse events between a contact isolation group with vancomycin-resistant Enterococcus (VRE) and a matched comparison group using a relatively large data set from full electronic medical records (EMR) and propensity score–matching methods.

DESIGN, SETTING, AND PARTICIPANTS This retrospective, matched cohort study was conducted at Seoul National University Bundang Hospital (SNUBH) in Korea, a tertiary, university-affiliated hospital that has 1337 inpatient beds. Participants included a total of 98,529 hospitalized adult patients (aged ≥18 years) during 2015 to 2017.

EXPOSURES Contact isolation in a single or shared double room.

MAIN OUTCOMES AND MEASURES As adverse contact isolation–related outcomes, falls and pressure ulcers were included. All relevant EMR data were extracted from the SNUBH clinical data warehouse. Risk factors for adverse events were included in the propensity score model based on literature reviews, such as Braden scale score and Hendrich II fall risk score. A fine stratification and weighting (FSW) and a 1:10 nearest neighbor (NN) propensity score matching as a sensitivity analysis were adopted to compare adverse events between the 2 groups for the observation period from the study entry date and the exit date. Time-to-event analyses with a Cox proportional hazard model were conducted in December 2021.

RESULTS For comparison of outcomes in wards, 177 patients (mean [SD] age, 67.38 [14.12] years; 98 [55.4%] female) with VRE and 93,022 patients (mean [SD] age, 56.44 [16.88] years; 49,462 [53.2%] female) without VRE were included and no difference was found in basic characteristics from the FSW (VRE contact isolation [n = 172] vs comparison [n = 69,434]) as well as from the 1:10 NN (VRE contact isolation [n = 168] vs comparison [n = 1650]). Among 177 patients with VRE contact isolation, 8 pressure ulcers and 3 falls occurred during their hospital stays; incidence rates of adverse events were 2.5 and 0.9 per 1000 patient-days, respectively (pressure ulcer incidence rate from the FSW: 2.53 per 1000 patient-days [95% CI, 1.09-4.99 per 1000 patient-days]; pressure ulcer incidence rate from the 1:10 NN: 2.54 per 1000 patient-days [95% CI, 1.10-5.01 per 1000 patient-days]; fall incidence rate from the FSW: 0.87 per 1000 patient-days [95% CI, 0.18-2.54 per 1000 patient-days]; fall incidence rate from the 1:10 NN: 0.87 per 1000 patient-days [95% CI, 0.18-2.55 per 1000 patient-days]). The hazard ratios for adverse events showed no statistically significant

Key Points

Question Is contact isolation associated with more adverse events among patients with vancomycin-resistant Enterococci (VRE)?

Findings In this cohort study of 98,529 hospitalized adult patients in Korea, no significant difference was found in the incidence of falls and pressure ulcers among patients with VRE contact isolation compared with patients without contact isolation.

Meaning These findings suggest that contact isolation for patients with multidrug-resistant organisms should not be discouraged on the basis of concerns about a greater likelihood of unintended adverse events.

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Abstract (continued)
differences for both groups: 1.42 (95% CI, 0.67-2.99) for pressure ulcer and 0.66 (95% CI, 0.20-2.13) for fall from the FSW.

CONCLUSIONS AND RELEVANCE In this cohort study, no association was found between the likelihood of adverse events and contact isolation using propensity score–matching methods and closely related covariates for adverse events.

Introduction

Contact isolation (ie, patient isolation with contact precautions) has been widely recommended for epidemiologically important, contact-transmissible health care–associated pathogens (eg, vancomycin-resistant Enterococcus [VRE]). However, with the increasing number of multidrug-resistant organisms (MDRO) and more patients under contact isolation, many hospitals have struggled to implement appropriate contact isolation given limited resources; for example, it requires longer stays in the emergency department and is nearly twice as time-consuming to assign inpatient beds. Contact isolation also causes financial burdens on hospitals, such as nonreimbursed screening surveillance costs and the opportunity cost of lost bed-days due to additional length of stay (LOS). Moreover, based on ineffective components of routine contact isolation (eg, fewer health care personnel [HCP] visits due to time-intensive use of personal protective equipment each visit), some studies have reported an association between contact isolation and unintended adverse events (eg, fall and pressure ulcer), which include supportive care failure; poor hospital administrative coordination; increased depression, anxiety, and delirium; and patient dissatisfaction. Furthermore, once contact isolation is implemented, deciding when contact isolation can be discontinued or if it should be continued for a readmitted patient is difficult because the proper duration of contact isolation has not been identified.

Since Steffox et al reported that contact isolation was associated with twice the likelihood for adverse events in 2003, many HCP have become conscious about contact isolation–related adverse events. According to an onsite survey conducted with 34 voluntary participants at the 2011 Infectious Diseases Society of America meeting, 74% showed concern about contact isolation–related patient harms, and only 38% believed contact isolation prevents MDRO transmission. With this concern, several studies have reported no significantly increased incidence of MDRO after discontinuation of contact isolation with horizontal infection control interventions such as daily chlorhexidine gluconate bathing. Subsequent studies also reported higher incidences of adverse events among contact isolation patients using different study designs such as retrospective cohort, observational quasi-experimental, and propensity score–matched cohort. Conversely, few studies provided counterevidence that contact isolation patients were less likely to experience preventable adverse events. Additionally, after implementing contact isolation discontinuation, the trend of adverse events was observed in a different direction; decrease vs no changes. With no universally applicable recommendations on contact isolation discontinuation or duration, according to the 2016 Society for Healthcare Epidemiology of America research network survey, 90% of participating institutions used contact isolation, 61% had a contact isolation discontinuation policy, 55% used screening tests for discontinuation, and 46% required 3 negative results for contact isolation discontinuation for VRE.

Given insufficient evidence for this controversial association between contact isolation and adverse events, this study aimed to compare adverse events between a VRE contact isolation group and a matched comparison group using a relatively large data set (ie, a full electronic medical record [EMR] for all hospitalized patients) and propensity score–matching methods with fine stratification and weighting (FSW).
Methods

Ethics
This study was approved by Seoul National University Bundang Hospital (SNUBH)'s institutional review board. An informed waiver from included patients was granted because EMR data were deidentified for data analysis. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Setting and Database
This retrospective cohort study was conducted at SNUBH, which has 1337 inpatient beds and is equipped with a full EMR system for all patient records. SNUBH has maintained a clinical decision support system for antibiotic prescription and a strict contact isolation policy for patients who are VRE colonized or VRE infected since its opening in 2003; contact isolation discontinuation requires 3 consecutive weekly negative culture results from contact isolation surveillance tests on the original site and a rectal or stool specimen. All relevant EMR data for adult patients (aged ≥18 years) who were hospitalized from 2015 to 2017 were extracted from the SNUBH clinical data warehouse. Along with the VRE contact isolation patient list provided by the infection control service, all contact isolation–related information of patients with VRE were confirmed through EMR manual review by 1 trained research nurse. All contact isolation-VRE patients’ transfer information with VRE initial culture results were manually double-checked through extracted EMR data sets by 1 of the coprincipal investigators.

Outcomes and Risk Factors
For adverse event outcomes, we included (1) pressure ulcers and (2) falls, which are patient safety indicators.19,20 Risk factors for adverse events were included in our propensity score model based on literature reviews: age, sex, diabetes, hypertension, hypoalbuminemia, Charlson comorbidity index (CCI) score, Braden scale score (for pressure ulcer), and Hendrich II fall risk.21 CCI score was calculated based on patients’ International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10) diagnosis codes at the time of admission to wards. Acute Physiology and Chronic Health Evaluation (APACHE) II scores were evaluated at the time of intensive care unit (ICU) admission for supplementary analysis of ICU patients. The Braden scale score and Hendrich II fall risk score were available for each patient from nursing EMR records because the SNUBH Nursing Department has emphasized preventing pressure ulcers and falls for better nursing care quality. Because LOS could be a potential confounding factor for our study outcomes,22 we examined LOS additionally.

Propensity Score Matching
First, we mainly focused on contact isolation patients who were admitted to wards based on the assumption that these patients would have fewer HCP visits and shorter HCP contact times.23,24 We excluded contact isolation patients who had any adverse events prior to their isolation start dates, were admitted to ICU within the first 2 days of hospital admission, and had VRE reports on or after their discharge. In case of readmissions with VRE, the first admission episodes with VRE culture-positive results were included. For potential matching non-contact isolation patients, patients with ICU admission within the first 2 days of hospital admission were excluded. To compare contact isolation–associated adverse events between the VRE contact isolation (VRE isolated) patient group and matched comparison (no contact isolation; no VRE) group, we adopted 2 types of propensity score–matching methods: (1) FSW as a main approach because propensity score–based stratification with fine strata produces the most accurate results for exposures with less than 5% prevalence of outcomes25 and (2) 1:10 nearest neighbor (NN) matching with a caliper 0.1 as a sensitivity analysis; 1:10 NN matching was selected to increase statistical power due to exceptionally rare adverse events.26
The retrospective observation period was from the study entry date (ie, contact isolation start date) to the study exit date (ie, discharge or discontinuance of contact isolation; Figure 1A). However, because matched non-VRE patients did not have any dates to substitute for contact isolation or ending observation indication, we had to randomly assign the index date which was created similar to the distribution of VRE contact isolation patients’ study entry dates for matched patients without VRE, with discharge date as the study exit date.

Furthermore, although ICU patients probably did not receive fewer HCP visits as assumed with contact isolation in wards, we supplementarily examined the patients with VRE who were admitted to ICU and had VRE culture–positive results prior to or during the ICU stay to evaluate ICU patients’ contact isolation-related negative outcomes. ICU patients with multiple unit transfers (including step-down units) were excluded due to unclear information about the timing of potential VRE acquisition and contact isolation length’s correlation between transfers.

**Statistical Analysis**

Time-to-event analyses with a Cox proportional hazard model were conducted using SAS software 9.4 (SAS Institute) for FSW and R version 3.5.2 (R Project for Statistical Computing) for 1:10 NN matching in December 2021. SAS macros for FSW propensity score matching were adopted from the Rishi Desai Dataverse.27 For group comparison before and after matching, standardized mean differences were calculated with a threshold of 0.2. For all adverse events that were low-prevalence outcomes, the Firth penalized maximum-likelihood estimation was applied. For the hazard ratio comparison between the groups, \( P < 0.5 \) was considered statistically significant and testing was 2-sided. In addition, incidences per patient day with 95% CIs were calculated to compare the occurrence of adverse events.

**Results**

For the 3 years of the study period, data were extracted for a total of 98 529 patients (325 VRE positive [0.3%]; 98 204 without VRE). After excluding patients with prior events before the contact isolation or index date, ICU admission within the first 2 days of hospital admission, and VRE report...
after discharge, 177 VRE patients who were admitted to wards and 93,022 hospitalized patients with no VRE history were included for propensity score matching (Figure 1B). Among the 177 patients with VRE included in the study, the mean (SD) age was 67.38 (14.12) years; 55.4% (n = 98) were female, 46.3% (n = 81) were at risk of pressure ulcer in the Braden scale, and 54.9% (n = 95) were categorized as high risk by the Hendrich II fall risk model at the time of admission; the mean (SD) LOS was 36.24 (36.60) days (Table 1). Among the 93,022 patients with no VRE history, the mean (SD) age was 56.44 (16.88) years and 49,462 (53.2%) were female.

From the FSW analysis, the VRE contact isolation group (n = 172; 97% of 177 total patients with VRE contact isolation) and the matched comparison (no contact isolation) group (n = 69,434; 75% of 93,022 total patients without contact isolation) showed no difference in baseline comparisons (Table 1). No difference was found in characteristics comparisons between the VRE contact isolation group (n = 168; 95%) and the matched group (n = 1,650; 1.8%) from the 1:10 NN analysis. After propensity score matching, standardized mean differences were less than 0.2, which showed relatively better in FSW compared with 1:10 NN matching (Figure 2). Mean (SD) LOS in the comparison group were 12.21 (13.10) days in FSW and 11.98 (11.94) days in 1:10 NN matching, which was significantly shorter compared with the VRE contact isolation group’s mean (SD) LOS which were 36.65 (36.77) days and 36.02 (36.61) days, respectively.

Among 177 patients with VRE contact isolation, 8 pressure ulcers and 3 falls occurred during their hospital stays; incidence rates of adverse events were 2.5 and 0.9 per 1000 patient-days.

### Table 1. Group Comparisons Before and After Propensity Score Matching for Patients’ Characteristics

| Characteristics | Before matching | After fine stratification and weighting | After 1:10 nearest neighbor |
|-----------------|-----------------|----------------------------------------|----------------------------|
|                 | Patients, No. (%) | Matched comparison (n = 93,022) | SMD | Patients, No. (%) | Matched comparison (n = 93,022) | SMD | Patients, No. (%) | Matched comparison (n = 1650) | SMD |
| VRE contact isolation | n = 177 | | | n = 172 | | | n = 168 | | |
| Age, mean (SD), y | 67.38 (14.12) | 56.44 (16.88) | 0.703 | 67.41 (14.22) | 68.33 (16.12) | 0.060 | 67.62 (14.29) | 69.54 (14.83) | 0.132 |
| Sex | | | | | | | | | |
| Male | 79 (44.6) | 43,560 (46.8) | 0.044 | 77.0 (44.8) | 31,074 (44.8) | <0.001 | 75.4 (44.6) | 743 (45.0) | 0.008 |
| Female | 98 (55.4) | 49,462 (53.2) | | 95.0 (55.2) | 38,359 (55.2) | | 93.5 (55.4) | 907 (55.0) | |
| Diabetes | | | | | | | | | |
| No | 127 (71.8) | 79,481 (85.4) | 0.339 | 123.0 (71.5) | 48,441 (69.8) | 0.038 | 120.4 (71.4) | 1181 (71.6) | 0.003 |
| Yes | 50 (28.2) | 13,541 (14.6) | | 49.0 (28.5) | 20,993 (30.2) | | 48.2 (28.6) | 469 (28.4) | |
| Hypertension | | | | | | | | | |
| No | 102 (57.6) | 64,997 (69.9) | 0.257 | 100.0 (58.1) | 39,491 (56.9) | 0.026 | 97.6 (57.7) | 915 (55.5) | 0.046 |
| Yes | 75 (42.4) | 28,025 (30.1) | | 72.0 (41.9) | 29,943 (43.1) | | 71.4 (42.3) | 735 (44.5) | |
| Hypoalbuminemia | | | | | | | | | |
| No | 115 (65.3) | 11,579 (14.5) | 1.214 | 58.0 (33.7) | 21,655 (31.2) | 0.054 | 110 (65.5) | 1055 (63.9) | 0.032 |
| Yes | 61 (34.7) | 68,196 (85.5) | | 114.0 (66.3) | 47,764 (68.8) | | 58 (34.5) | 595 (36.1) | |
| Charlson comorbidity index, mean (SD) | 2.06 (2.57) | 0.83 (1.55) | 0.578 | 2.03 (2.59) | 1.89 (2.68) | 0.076 | 2.04 (2.53) | 1.86 (2.60) | 0.072 |
| Braden scale score category | | | | | | | | | |
| No risk (<12) | 94 (53.7) | 78,956 (83.5) | 1.017 | 91.0 (52.9) | 36,962 (53.2) | 0.026 | 89.3 (53.0) | 869 (52.7) | 0.062 |
| Low risk (13-14) | 36 (20.6) | 3581 (4.2) | | 36.0 (20.9) | 15,008 (21.6) | | 36 (21.4) | 390 (23.6) | |
| Medium risk (15-18) | 24 (13.7) | 1112 (1.3) | | 24.0 (14.0) | 9407.0 (13.5) | | 24 (14.3) | 213 (12.9) | |
| High risk (≥19) | 21 (12.0) | 822 (1.0) | | 21.0 (12.2) | 8056.3 (11.6) | | 19 (11.3) | 178 (10.8) | |
| Hendrich II fall risk model score category | | | | | | | | | |
| Low risk (<5) | 78 (45.1) | 71,436 (84.6) | 0.908 | 77.0 (44.8) | 30,233.2 (43.5) | 0.025 | 75.4 (44.6) | 695 (42.1) | 0.051 |
| High risk (≥5) | 95 (54.9) | 13,027 (15.4) | | 95.0 (55.2) | 39,200.8 (56.5) | | 93.5 (55.4) | 955 (57.9) | |
| Length of stay, mean (SD), d | 36.24 (36.60) | 6.23 (7.80) | 1.134 | 36.65 (36.77) | 12.21 (13.10) | 0.885 | 36.02 (36.61) | 11.98 (11.94) | 0.883 |

Abbreviations: SMD, standardized mean difference; VRE, vancomycin-resistant Enterococci.
respectively, in both propensity score–matching approaches (pressure ulcer incidence rate from the FSW: 2.53 per 1000 patient-days [95% CI, 1.09-4.99 per 1000 patient-days]; pressure ulcer incidence rate from the 1:10 NN: 2.54 per 1000 patient-days [95% CI, 1.10-5.01 per 1000 patient-days]; fall incidence rate from the FSW: 0.87 per 1000 patient-days [95% CI, 0.18-2.54 per 1000 patient-days]; fall incidence rate from the 1:10 NN: 0.87 per 1000 patient-days [95% CI, 0.18-2.55 per 1000 patient-days]) (Table 2). The hazard ratios for adverse events showed no statistically significant differences for both groups: 1.42 (95% CI, 0.67-2.99) for pressure ulcer and 0.66 (95% CI, 0.20-2.13) for fall from the FSW (Table 3).

Among 124 patients with VRE who were admitted or transferred to ICU, 21 patients with VRE ICU contact isolation were included for the analysis after excluding inappropriate cases, such as multiple unit transfers and short stay less than 24 hours after reporting VRE culture positive. However, because their adverse events were rare (ie, 0 pressure ulcers; 1 fall), we could not proceed with more analysis.

Table 2. Incidence Results for Adverse Events Between VRE Contact Isolation Group vs Matched Comparison Group

| Adverse events | Group | No. of events | Cumulative patient-days | 1000 Patient-day incidence (95% CI) | Incidence rate ratio | No. of events | Cumulative patient-days | 1000 Patient-day incidence (95% CI) | Incidence rate ratio |
|----------------|-------|---------------|-------------------------|--------------------------------------|----------------------|---------------|-------------------------|--------------------------------------|----------------------|
| Pressure ulcer | VRE contact isolation | 8 | 3157 | 2.53 (1.09-4.99) | 1.65 (0.76-3.07) | 8 | 3146 | 2.54 (1.10-5.01) | 2.09 (0.89-4.92) |
| Matched comparison | 879 | 531465 | 1.65 (1.55-1.77) | 1.29 (1.19-1.39) | 15 | 12344 | 1.22 (0.68-2.00) | 1.54 (0.93-2.40) |
| Fall | VRE contact isolation | 3 | 3464 | 0.87 (0.18-2.54) | 0.68 (0.22-2.10) | 3 | 3435 | 0.87 (0.18-2.55) | 0.57 (0.17-1.92) |
| Matched comparison | 698 | 542294 | 1.29 (1.19-1.39) | 1.29 (1.19-1.39) | 19 | 12355 | 1.54 (0.93-2.40) | 1.54 (0.93-2.40) |
| All | VRE contact isolation | 11 | 3068 | 3.59 (1.79-6.42) | 1.21 (0.67-2.20) | 11 | 3057 | 3.60 (1.80-6.44) | 1.29 (0.65-2.54) |
| Matched comparison | 1548 | 524803 | 2.95 (2.80-3.10) | 2.95 (2.80-3.10) | 34 | 12191 | 2.79 (1.93-3.90) | 2.79 (1.93-3.90) |

Abbreviations: FSW, fine stratification and weighting; PSM, propensity score matching; VRE, vancomycin-resistant Enterococci.

Table 3. Cox Proportional Hazard Model Results for Adverse Events between VRE Contact Isolation Group vs Matched Comparison Group

| Matching methods | Characteristics | Pressure ulcer | Fall | All |
|------------------|-----------------|----------------|------|-----|
|                  |                 | HR (95% CI)    | P value | HR (95% CI)    | P value | HR (95% CI)    | P value |
| Unmatched        | VRE (yes)       | 2.06 (1.00-4.26) | .05  | 0.69 (0.22-2.17) | .52  | 1.48 (0.81-2.73) | .20  |
| FSW              | VRE (yes)       | 1.42 (0.67-2.99) | .36  | 0.66 (0.20-2.13) | .48  | 1.14 (0.61-2.12) | .68  |
| 1:10             | VRE (yes)       | 2.07 (0.85-5.01) | .11  | 0.60 (0.17-2.13) | .43  | 1.28 (0.63-2.60) | .49  |

Abbreviations: FSW, fine stratification and weighting; HR, hazard ratio; VRE, vancomycin-resistant Enterococci.
Discussion

This cohort study found no significant difference in the incidence of adverse events between the VRE contact isolation group and matched comparison group using the 2 different propensity score-matching approaches reflecting most of the potential covariates and a relatively large data set from 3 years of SNUBH’s full EMR. Our study provided supporting evidence that contact isolation for MDRO patients should not be discouraged due to concerns about unintended pressure ulcers and falls while previous studies on this topic adopted different approaches and reported a likelihood of association between contact isolation and adverse events more favorably.

When Steffox et al reported significantly more adverse events in patients under isolation in 2003, many researchers showed concerns over the validity of the study design and approach, such as unmatched basic patient characteristics (eg, preexisting diabetes which is a risk factor for pressure ulcers) and the unadjusted time-dependent nature of adverse events (ie, the longer LOS and the higher cumulative nature of negative events). A decade later, a retrospective cohort study by Gandra et al reported significantly higher rates of adverse events among contact isolation patients, but the results were estimated from a random 1:1 matching on hospital unit and admission date with plus and minus 30-day ranges. More recently, Martin et al reported a reduction of adverse events after routine contact isolation elimination adopting retrospective, quasi-experimental designs with comparison preintervention and postintervention outcomes and 4 databases, including the National Healthcare Safety Network. However, they included not only pressure ulcers and falls, but also postoperative adverse events (eg, respiratory failure, hematoma, pulmonary embolism, thrombosis, and wound dehiscence). Because previously published studies on contact isolation related to adverse events used different approaches and covariates along with various adverse event types, careful attention is necessary to compare their results.

Nonetheless, we believe the propensity score-matching approach provides benefits to evaluate the contact isolation-related adverse events, because of the inherent confounding attributable to the different distribution of subject characteristics in observational studies when randomized controlled trials are inapplicable and conventional regression adjustment’s limitations for binary or time-to-event nature outcomes. In addition, a multivariable regression adjustment provides participant-specific target estimands, while propensity score-matching methods provide population-average target estimands which are similar to randomized clinical trials. Therefore, propensity score-matching methods are better approaches for contact isolation-related adverse events like falls or pressure ulcers which are time-to-event in nature.

In addition to adopting propensity score-matching methods for covariate adjustment, it is important to include appropriate covariates which can be confounding factors for outcome variables in propensity score-matching models. Using a propensity score-matching method and case-mix group, Tran et al reported that contact isolation was associated with adverse events and may cause poorer patient outcomes. However, their 9 covariates included relatively unrelated factors for adverse events (eg, month and year of isolation, admission site) and did not reflect most of the related risk factors for falls or pressure ulcers like our study. Despite the clear importance of risk assessment for adverse events, the Braden scale score for pressure ulcers and Hendrich II fall risk score have not been considered for adjusting risk factors for falls or pressure ulcers in published studies for comparisons of contact isolation-related adverse events. The Braden scale for estimating pressure ulcer risk has been used to assess patients’ pressure ulcer risk since 1987, based on 6 components: sensory perception to pressure-related discomfort; moisture exposure; degree of physical activity; mobility to change body position; nutrition status with food intake pattern; and friction with surfaces. The Hendrich II fall risk score, which showed 74.9% sensitivity and 73.9% specificity, has been adopted to examine patients’ fall risk based on 8 risk factors: confusion, depression, altered elimination, dizziness, male sex, administration of antiepileptics or benzodiazepines, and poor performance of getting up and/or going from a seated position. These 2 assessment scales were developed by nurses and have been used to estimate which patients are at risk for falls or pressure ulcers.
risk so that nurses can implement preventive interventions. The study hospital’s full EMR records with the nursing department’s assessment records and efforts to prevent falls and pressure ulcers enabled us to use these variables for adjusting the actual risks for adverse events.

Longer contact isolation LOS is expected to have a higher cumulative risk of adverse events and our VRE contact isolation group had a significantly longer LOS. However, after propensity score matching including LOS, we found no difference in the hazard ratios of adverse events between the 2 groups in both propensity score–matching approaches. In our study, the low incidence rate of adverse events among VRE contact isolation patients may affect the study results and may be induced by the nursing department’s successful emphasis on preventing falls and pressure ulcers, which are regarded as nursing care quality indicators. Compared with the trend of contact isolation elimination based on successful MDRO reduction with horizontal approaches (eg, universal decolonization with chlorhexidine bathing) in US hospitals where most inpatient rooms are spacious or single rooms, Korean hospitals which maintain strict contact isolation and have more shared inpatient rooms are currently facing shortages of single isolation rooms for increasing MDRO. Our results are Korean hospital-specific, as the actual Korean nursing staffing level is much lower than in the US, so the results may differ for US hospitals. Further study may need to compare contact isolation–related adverse events with nursing staffing levels and levels of nursing care. In addition, it may be valuable to conduct further contact isolation–related adverse events comparison study between Magnet-designated hospitals and non-Magnet hospitals in the US, because Magnet recognition through the American Nurses Credentialing Center can be considered for nursing excellence, lower nurse turnover, and better patient outcomes and satisfaction. Although a Magnet recognition program does not exist in Korea, the study hospital is one of the top-ranked university-affiliated tertiary hospitals with these nursing efforts. Therefore, this study’s results may not be generalizable to other Korean hospitals that do not emphasize nursing interventions to prevent adverse events.

In addition to this study’s strength that included risk factors as covariates for propensity score–matching model from literature review for adverse events which were not included in the previously published studies, this study adopted the FSW approach for adjusting confounders for infrequent exposures. By examining 1:10 NN matching as a sensitivity analysis, we could validate the study results better; standardized mean differences for each variable between the VRE contact isolation group and matched comparison group were less than 0.2, which indicates well-balanced with no differences.

Limitations

This study has several limitations. First, this study’s results would not be generalizable to other hospitals that have different service, environments, patient populations, and VRE prevalence; actual statistical difference could not be verified due to rare adverse events among VRE contact isolation patients from a single hospital. Second, in fact, CCI has not been verified for adjusting confounding factors in studies of multidrug-resistant organisms. The Elixhauser comorbidity index seems better than CCI in terms of estimating mortality for administrative data. However, because the Korean reimbursement system does not use Diagnosis-Related Groups, which are necessary to calculate Elixhauser comorbidity index scores, we had to use CCI to compare patients’ comorbidities. Third, we did not examine other contact isolation–related adverse outcomes, such as medication errors, deep vein thrombosis, increased anxiety, depression, and lower satisfaction among contact isolation patients. Fourth, despite most advanced SNUBH’s EMR/Clinical Data Warehouse in Korea, due to the impossibility of whole component data extraction at once, data extraction for each component was time-consuming, data cleaning with several differently structured files from each database was complicated requiring manual reviews, diligent efforts of research teams were made to seek better propensity score–matching methods application, our research completion took longer than expected; and our data became relatively older. For further studies, the development of consolidated data extraction at once from each user-friendly interface (eg, physician diagnosis, nursing, and
laboratory) for research purposes given the hospital EMR system would be helpful in terms of avoiding manual processing. Fifth, despite our efforts to compare adverse events between ICU patients with VRE contact isolation and other ICU patients, we could not compare outcomes due to frequent transfer cases and rare adverse events. Studies on adverse events among MDRO ICU patients, even under close watch in open ICU settings, may be of research interest due to their severity of illness or other attributing factors.

Conclusions

Using different propensity score–matching approaches and closely related covariates for adverse events, our study found no association between the likelihood of adverse events and contact isolation based on the full EMR records for 3 years. Although recent trends of horizontal approach with contact isolation elimination show meaningfully associated results, given no strong evidence of an association between contact isolation and adverse events, contact isolation policy making needs to be carefully decided based on risk-benefit evaluation for each hospital.
Meeting Presentation: This study abstract for a preliminary result (ie, the 1:1 nearest neighbor propensity score matching) was accepted by the 6th Decennial International Conference on Healthcare Associated Infections as a poster presentation (#645); March 28, 2020; Atlanta, Georgia.

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