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State of the Science Review

# Does the removal of isolation for VRE-infected patients change the incidence of health care–associated VRE?: A systematic review and meta-analysis

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*Key Words:*
Patient isolation
Cross-infection
Multiple drug resistance

***Background:*** Several single-center studies have suggested that eliminating isolation for vancomycin-resistant enterococci (VRE) control in the context of endemic or nonoutbreak settings, has no impact on infection rates. We performed a systematic review and meta-analysis on the impact of discontinuing isolation.
***Methods:*** We searched PubMed, Embase, the Cochrane Library, and Web of Science through April 10, 2024 for studies evaluating discontinuation of isolation for VRE. Subgroup analyses assessed sources of heterogeneity.
***Results:*** Nine studies were included in the final review. Four reported the incidence of hospital-acquired VRE (HA-VRE) infections and 5 reported the incidence of hospital-acquired VRE bloodstream infections (HA-VRE BSI). No significant difference between the rates of HA-VRE infection before and after stopping isolation was observed (risk ratios, 0.93; 95% confidence interval, 0.68-1.26; $P$ = .62), as well as no significant difference on the incidence of HA-VRE BSI (risk ratios, 0.68; 95% confidence interval, 0.44-1.07, $P$ = .09). Furthermore, we conducted 2 subgroup analyses: one stratified by whether the studies were conducted during Coronavirus Disease 19 (COVID-19), and the other stratified by whether clinicians continued to use personal protective equipment. Both analyses revealed no significant differences in the incidence of HA-VRE BSI and termination of isolation between the subgroups.
***Conclusions:*** In the context of endemic or nonoutbreak settings, discontinuation of isolation for VRE patients has not been associated with an increased rate of HA-VRE infections.


## BACKGROUND

In 2019, the Antibiotic Resistance Threats Report published by the Centers for Disease Control and Prevention classified vancomycin-resistant enterococci (VRE) as a severe threat.[1] A systematic review of the epidemiology and outcomes of VRE shows that the incidence of VRE was reported inconsistently and infrequently, the range of VRE infection rates across different studies or settings was wide (1%-55%), and the mortality rate of patients with VRE faecium bloodstream infections (BSIs) is 1.46 times higher than that of patients with vancomycin-sensitive Enterococcus faecium BSIs.[2,3]

Immunocompromised patients are susceptible to VRE infections, and there is a limited choice of antibiotics available to treat VRE infections when they occur. VRE can be transmitted from patient to patient through contact with contaminated health care workers, environmental surfaces, or medical equipment.[1] To prevent the challenge of controlling the deadly and costly infections associated with VRE, a bundle of contact precautions (CPs) have been

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Conflicts of interest: None to report.

Ethics approval: This is a systematic review and meta-analysis and no ethics approval indicated for this study. However, the study was preregistered in PROSPERO (registration number CRD42024535541).

Availability of data and materials: Data included in the study or supplementary material or referenced in the study.

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0196-6553/

recommended for VRE-infected or colonized patients, such as the use of personal protective equipment (PPE) (the use of gowns and gloves), isolation in a single-room or cohort, hand hygiene (HH), decolonization with chlorhexidine (CHG) bathing, and environmental disinfection practices.[1,4–6] However, in the context of endemic or nonoutbreak settings, the need for CPs (such as the use of PPE) for patients with VRE colonization or infection is currently controversial, and the impact of stopping single-room or cohort isolation on hospital-associated VRE infection rates is not known.[7–15]

Recent researchers have questioned the necessity of single-room or cohort isolation for VRE patients in endemic or nonoutbreak settings, finding no evidence of increased incidence of hospital-acquired VRE (HA-VRE) infections or hospital-acquired VRE BSIs when HH compliance is high.[10–13,16–20] Further, a growing body of research has found that the isolation of patients may be associated with medication errors, fewer physician and nurse visits, safety issues such as increased falls and pressure ulcers, patient anxiety and depression, and significant increases in the cost of care.[21] Therefore, in this systematic review and meta-analysis, we synthesized existing studies to assess the impact of discontinuing single-room or cohort isolation of VRE patients on hospital-associated VRE infection rates.

## METHODS

The study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and Joanna Briggs Institute methodology for systematic review guidelines.[22] This review was registered in the International Prospective Register of Systematic Reviews—PROSPERO (CRD42024535541). No ethical approval was required.

### *Search strategy*

We searched PubMed, Embase, the Cochrane Library, and Web of Science databases by using keywords related to “patient isolation” and “vancomycin-resistant enterococcus” to construct the search strategies. For details of the search strategy, please see Supplementary 1. The search period was from the date of database creation to April 10, 2024, with no language restriction. We also reviewed the citations within the final included studies to search for relevant studies.

### *Inclusion and exclusion criteria*

Studies were included if they matched the following criteria: involved human inpatients; in hospitals that had stopped isolating patients with VRE; and controlled trial or quasi-experimental study design. Exclusion criteria: under the age of 18; only abstracts but no full texts were available; no report of VRE occurrence; studies with incomplete data, such as protocols; or outbreak studies.

### *Literature selection and data extraction*

Studies retrieved from each database were imported into the literature management software NoteExpress 3.7.0.9296 (NoteExpress, Aiqin Haile Technology Co, Ltd). The titles and abstracts of all studies were independently screened by 2 reviewers, Huiling Pan (P.H.L.) and Jie Song (S.J.), to obtain full-text studies that met the inclusion criteria and were independently reviewed by 2 evaluators (P.H.L. and S.J.). Inconsistencies in the included studies were discussed by the 2 reviewers (P.H.L. and S.J.), and if disagreements persisted, a third reviewer, Chunalai Zhang (Z.C.L.), was consulted to reach consensus.

Data extraction was performed by one reviewer (P.H.L.) and subsequently checked by another reviewer (S.J.). The extracted data included authors, year of publication, country, time of stopping isolation, duration of study, study design, the number of beds in the study center, type of study center and department, active surveillance status, adherence surveillance status, infection control measures, incidence of hospital-associated VRE infection rates, and incidence of hospital-associated VRE BSI rates. The tool used for data extraction was an Excel spreadsheet developed and designed by the authors.

### *Quality assessment*

The main outcomes of interest in this study were the incidence of hospital-associated VRE infection and the incidence of hospital-associated VRE BSI. Therefore, the quality assessment tools used in this study are the ones suitable for before-after (pre-post) studies with no control group, namely the scale developed by Aboelela et al (5 aspects include 14 items, each item has a score of 1-4 points, of which 4 is the highest quality).[23] The evaluation was conducted independently by 2 reviewers (P.H.L. and S.J.), who discussed the inconsistency of quality assessment, but if the disagreement still existed, the third reviewer (Z.C.L.) was consulted to reach a consensus. All studies, regardless of methodological quality, were included in this review.

### *Statistical analysis*

Meta-analysis was performed using Review Manager 5.4 software (Revman, Cochrane Collaboration). The natural log of the risk ratios (RR) (preincidence to postincidence rate) and standard error of mean for VRE studies were calculated independently. Then, the pooled RR and its 95% confidence intervals (CIs) were estimated using the random-effects model of the inverse variance method. Heterogeneity between studies was evaluated by the $I^2$ statistic and the Cochran Q statistic. The funnel plot method was used to evaluate the publication bias. We planned to conduct subgroup analysis for the outcome of the hospital-acquired VRE BSIs based on whether clinicians continued to use PPE and whether the study was conducted during Coronavirus Disease 19 (COVID-19). A 2-tailed $P < .05$ was considered statistically significant in all tests.

## RESULTS

### *Search results*

The search result was 6,892 publications. After removing 1,354 duplicates, 5,538 studies were identified for screening. After screening the titles and abstracts according to the inclusion and exclusion criteria, 38 studies were selected for full-text review. Ten studies were excluded due to ineligible study aims. Figure 1 summarizes the reasons for excluding studies.

### *Characteristics of included studies*

As shown in Table 1 (see Supplementary 1 for details), 9 studies were included in the final review, and these studies were published between 2014 and 2024. A total of 5 countries participated in the publication of these studies, including 4 studies in the United States,[17–20] 2 studies in South Korea,[10,11] and the remaining 3 studies from Germany,[16] Canada,[12] and Denmark,[13] respectively. All studies used quasi-experimental designs; 8 were nonrandomized, comparing VRE infection rates pre- and post-discontinuation of single-room or cohort isolation; and 1[12] was a retrospective observational study. Six studies[10–12,16,19,20] were single-center, and 3[13,17,18] were multicenter. The setting for most (8/9) studies[10–13,17–20] was an

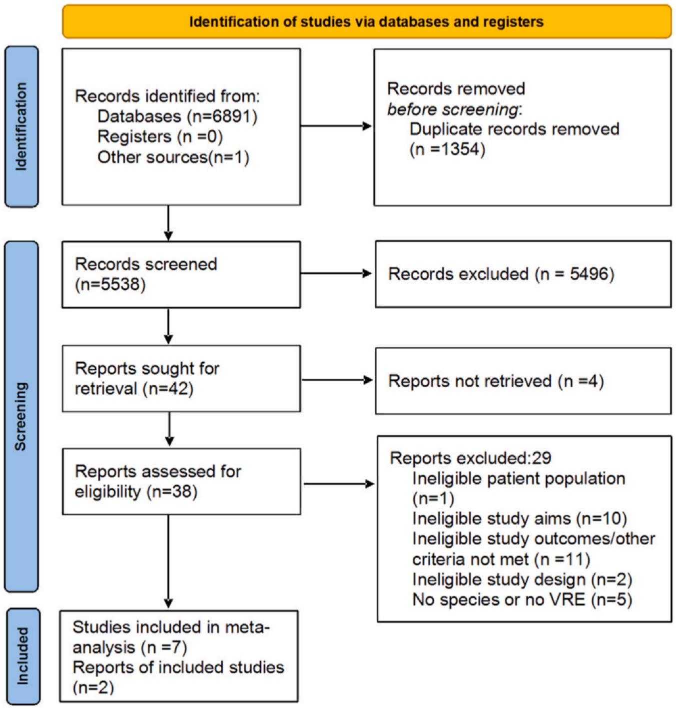


**Fig. 1.** Flowchart depicting the inclusion and exclusion of studies.

entire hospital, while 1 study[16] was specific to 8 adult intensive care units (ICUs) in a hospital.

The researchers reported outcomes in different ways. Three studies[16,17,20] reported the number of hospital-associated VRE infections per 1,000 patient days pre- and post-discontinuation of single-room or cohort isolation; 1 study[19] reported the number of VRE device–associated infections per 1,000 device days; 3 studies[10,16,19] reported the number of hospital-associated VRE BSIs per 1,000 patient days before and after discontinuation of isolation; 1 study[18] reported the number of hospital-associated VRE BSIs per 1,000 central venous catheterization days; and 1 study[11] reported the number of hospital-associated VRE BSIs per 100,000 patient days.

In 4 of the studies,[10–13] clinicians used PPE before and after discontinuation of isolation, with 2 of these studies[10,12] demonstrating that adherence to PPE use remained high. In contrast, 5 of the studies[16–20] showed that clinicians stopped using PPE after discontinuation of isolation. Similarly, active surveillance was performed by clinicians in 4 of the studies,[10,12,16,20] both before and after stopping isolation. Yet, in 2 studies,[11,13] VRE microbiologic surveillance was discontinued after stopping isolation. Six studies[10–12,17–19] monitored HH compliance, with 5[10–12,17,18] clinicians reporting high HH compliance rates both before and after stopping isolation (ranging from 84% to 96.4% in 4 studies,[10,11,17,18] while 1 study[12] did not provide specific data). The remaining study[19] did not report data on HH adherence. In 2 studies, clinicians administered CHG bathing daily to ICU patients.[10,18] In 1 study,[16] clinicians implemented daily antiseptic body washing with octenidine for ICU patients after stopping isolation. In 2 other studies,[17,19] clinicians administered CHG bathing daily to all patients. In 4 of the studies,[10,11,17,18] clinicians kept the environmental disinfection practices unchanged before and after discontinuation of isolation; in 2 studies,[13,16] clinicians intensified the frequency of cleaning and disinfection after stopping isolation. Environmental disinfection practices varied across studies, such as 2 studies[17,18] used ultraviolet light for disinfection daily, 1 study[13] used vaporized hydrogen peroxide for daily disinfection, and 1 study[10] used quaternary ammonium compound for daily disinfection with 96.4% adherence.

### *Quality evaluation results*

The quality assessment is shown in Table 2. The results of the assessment tool (1-4 scale) used by Aboelela et al showed that the average score of 9 studies was 3.0 (range 2.4-3.3). The included studies had the following characteristics: the research questions and objects were clearly explained, and all participants evaluated the results consistently. Five studies used an interrupted time series analysis design.[11,16–18,20] However, there are some problems, such as insufficient explanation of the baseline data of the study subjects, lack of explanation of the follow-up, and whether the outcome assessors were blinded to the participants' intervention status. In general, the overall quality of the studies included in the review was good.

### *Meta-analysis*

The studies conducted by Hansen et al[13] and Popiel et al[12] were not included in the meta-analysis because they did not report the data on hospital-associated VRE infection.

Data from 4 studies investigating the rates of hospital-associated VRE infection before and after removing single-room or cohort isolation were included in the meta-analysis (Fig 2).[16,17,19,20] The pooled analysis suggested that there was no statistically significant difference in the incidence of hospital-associated VRE infection before and after stopping single-room or cohort isolation (RR, 0.93; 95% CI, 0.68-1.26; $P = .62$). We did not notice any heterogeneity among these study findings ($I^2 = 0\%$, $P = .92$).

Data from 5 studies investigating the rates of hospital-associated VRE BSI before and after stopping single-room or cohort isolation were included in the meta-analysis (Fig 3).[10,11,16,18,19] The pooled analysis suggested no evidence of difference between rates of hospital-associated VRE BSI before and after discontinuation of single-room or cohort isolation (RR, 0.68; 95% CI, 0.44-1.07; $P = .09$). We did not notice any heterogeneity in these findings ($I^2 = 0\%$, $P = .43$). There was little evidence of publication bias for the outcomes of hospital-associated VRE infections (see Supplementary 2).

### *Subgroup analysis*

Two studies[10,11] investigated rates of hospital-associated VRE BSI before and after removing isolation that used PPE, while 3 studies[16,18,19] did not use PPE. The pooled analysis for studies using PPE suggested no evidence of difference between rates of hospital-associated VRE BSI before and after removing the isolation (RR, 0.84; 95% CI, 0.34-2.06; $P = .71$). Similarly, the pooled analysis for studies not using PPE also suggested no evidence of difference between rates of hospital-associated VRE BSI before and after removal of isolation (RR, 0.54; 95% CI, 0.28-1.04; $P = .06$). We did not notice any differences between these subgroups (test for subgroup differences: $P = .09$).

Two studies[10,11] investigated the rate of hospital-associated VRE BSI before and after stopping the isolation during COVID-19, while 3 studies[16,18,19] conducted studies during non-COVID-19. Since the study was consistent with the subgroup analysis of the rate of hospital-associated VRE BSI whether to use PPE, the effect indicators were equal and the results were consistent.

**Table 1**
Summary of characteristics of studies included in the systematic review

| First author, year, location | Study design | Year isolation discontinued | Study period (y) | Study setting (bedsize) | HH compliance | Other preventive and control measures | Outcome (rates of infection) |
|---|---|---|---|---|---|---|---|
| Park, 2024,[10] South Korea | QE | 2021 | 5 | Hospital (2,738) | Yes | AMSv; PPE; CHG bathing; EDP (QAC/d) | No impact on VRE BSI rate (VRE: 15 to 8 per 1,000 patient days) |
| Hansen, 2024,[13] Denmark | QE | 2022 | 8 | Hospitals (2,240) | NA | PPE; EDP (VHP/d) | No impact on VRE BSI rate (VRE: no rates were shown) |
| Chang, 2023,[11] Korea | QE | 2020 | 8 | Hospital (1,761) | Yes | PPE; EDP | No impact on VRE BSI rate (VRE: 11.5 to 9 per 100,000 patient days) |
| Eichel, 2022,[16] Germany | QE | 2018 | 4 | Hospital (2,000) | NA | AMSv; antiseptic with octenidine bathing/d; EDP | No impact on VRE HAI rate (VRE: 8.8 to 8.1 per 1,000 patient days); No impact on VRE BSI rate (VRE: 0.26 to 0.31 per 1,000 patient days) |
| Martin, 2022,[17] America | QE | 2018 | 2 | Hospital (4,542) | Yes | CHG bathing/d; EDP (UV/d) | No impact on VRE HAI rate (VRE: 0.5 to 0.5 per 1,000 patient days) |
| Haessler, 2020,[18] America | QE | 2004 (A); 2014 (B); 2013 (C) | 7 | Hospital (2,139) | Yes | CHG bathing/d; EDP (UV/d) | No impact on VRE BSI rate (VRE: 0.209 to 0.1 per 1,000 CVC days) |
| Edmond, 2015,[19] America | QE | 2013 | 2 | Hospital (865) | Yes | CHG bathing/d | No impact on VRE HAI rate (VRE: 22 to 17 per 1,000 device days); No impact on VRE BSI rate (VRE: 1.8 to 1.3 per 1,000 device days) |
| Popiel, 2014,[12] Canada | ROS | 2010 | 13 | Hospital (637) | Yes | AMSv; PPE | No rates were shown (all incidences other than colonization plateaued in long-term) |
| Gandra, 2014,[20] America | QE | 2010 | 2 | Hospital (781) | NA | AMSv | No impact on VRE acquisition rate (VRE: 1.39 to 0.016 per 1,000 patient days) |

*AMSv*, active microbiologic surveillance; *BSI*, bloodstream infection; *CHG*, chlorhexidine; *CVC*, central venous catheter; *EDP*, environmental disinfection practices; *HAI*, health care–associated infection; *HH*, hand hygiene; *NA*, not available; *PPE*, personal protective equipment; *QAC*, quaternary ammonium compound; *QE*, quasi-experimental (pre-post intervention comparison); *ROS*, retrospective observational study; *UV*, ultraviolet; *VHP*, vaporized hydrogen peroxide; *VRE*, vancomycin-resistant enterococci.

**Table 2**
Quality assessment of studies included

| | Park | Hansen | Chang | Eichel | Martin | Haessler | Edmond | Popiel | Gandra |
|---|---|---|---|---|---|---|---|---|---|
| *Representativeness* | | | | | | | | | |
| Study population description | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 4 |
| Inclusion and exclusion criteria | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 4 |
| Location and setting description | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 3 |
| *Bias and confounding* | | | | | | | | | |
| Study population corresponded to a large population in all key factors | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Masking | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| How similar was the assessment of outcomes between groups | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 |
| Involvement from the author | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 |
| Accounted for confounding interventions | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 2 | 2 |
| Compliance rates | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 3 |
| *Description of intervention* | | | | | | | | | |
| Replication possible given descriptions of intervention | 4 | 3 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| *Outcome and follow-up* | | | | | | | | | |
| Outcome assessment procedure clearly defined | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 |
| Groups equivalent in attrition, length of stay, death, or patient days | 3 | 4 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| *Statistical analysis* | | | | | | | | | |
| Description and appropriateness of methods | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 |
| Tested differences between groups and variability | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 1 | 3 |

## DISCUSSION

This study found that in the context of endemic or nonoutbreak settings, canceling single-room or cohort isolation for VRE patients did not affect the incidence of hospital-associated VRE infection or hospital-associated VRE BSI. This may be related to HH compliance of ≥84% before and after stopping isolation, daily chlorhexidine bathing, and having a good environmental disinfection protocol. At the same time, subgroup analysis of this study found that whether clinicians continued to use PPE and whether the study was conducted during COVID-19 had no impact on the study results.

Previous studies have mostly discussed the role of cluster interventions in preventing and controlling the generation and spread of VRE.[24,25] These measures usually include HH, decolonization with chlorhexidine bathing, PPE (the use of gowns and gloves), isolation in a single room or cohort, environmental disinfection practices, and so on. However, there is a lack of strong clinical trial evidence to support the role of an intervention in the prevention and control of VRE infection.[7,8,26] HH is crucial in preventing and controlling the spread of VRE, and higher HH compliance can block the spread of pathogens. In this systematic review, the HH compliance ≥84%, and the HH compliance was different before and after stopping isolation, which may have had an impact on the research results to some extent. Previous studies have shown that chlorhexidine or octenidine bathing can effectively reduce the colonization and infection rate of VRE.[27,28] In this systematic review, some studies used chlorhexidine or octenidine bathing for patients, but the included studies lacked data on bathing frequency and implementation rate before and after removing isolation, which is not conducive to the elaboration of the research results to a certain extent.[10,17–19] Moreover, according to previous studies, different environmental disinfection practices affect rates of multidrug-resistant organism (MDRO) colonization and infection.[29,30] In this systematic review, there are 2 studies in which the change in environmental disinfection practices after the removal of isolation interferes with the interpretation of research results to a certain extent. Nevertheless, it also shows that in the context of endemic or nonoutbreak settings, discontinuation of isolation for VRE patients has not been associated with an increased rate of HA-VRE infections, especially when the hospital maintains an adherence to HH practices of at least 84%, implements daily CHG bathing, and adheres to a robust protocol for environmental disinfection practices.

With the increase of single-occupancy rooms in medical centers in developed countries, more and more studies explore the incidence of MDRO colonization or infection after moving to a new hospital with 100% single-occupancy rooms.[31,32] Blane et al31 found that the VRE colonization or infection rate after relocation to a new hospital with all private rooms decreased significantly (incidence rate ratio: 0.56; 95% CI: 0.38-0.84).[31] Schoor et al also showed that moving to a new hospital with a 100% single ward significantly reduced the number of highly resistant microorganisms in the environment.[32] However, as stated in previous studies, the timing of the investigation and environmental disinfection practices before and after the relocation was not systematically detected, and there were a number of confounding factors.[31,32] In addition, these studies are single-center studies and still lack strong evidence to prove the impact of a 100% single-occupancy room on MDRO colonization or infection. Moreover, a growing number of studies have shown that isolation has certain concerns about the psychological and physiological safety of patients.[21] Isolation of patients may be related to

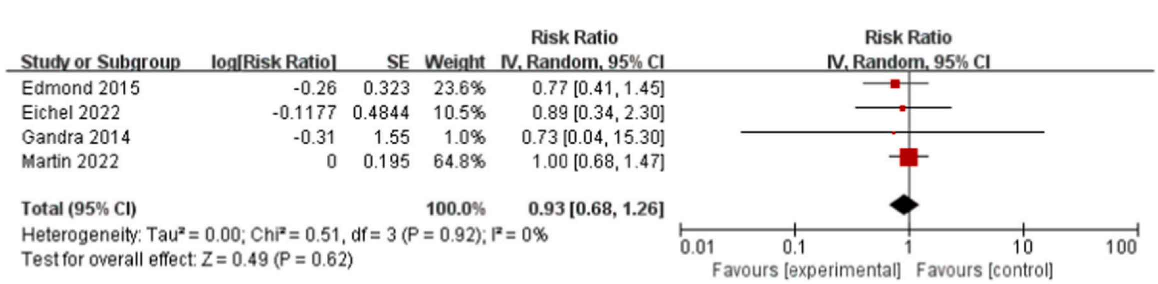


**Fig. 2.** Impact of stopping isolation on hospital-associated VRE infection. CI, confidence interval; SE, standard error; VRE, vancomycin-resistant enterococci.

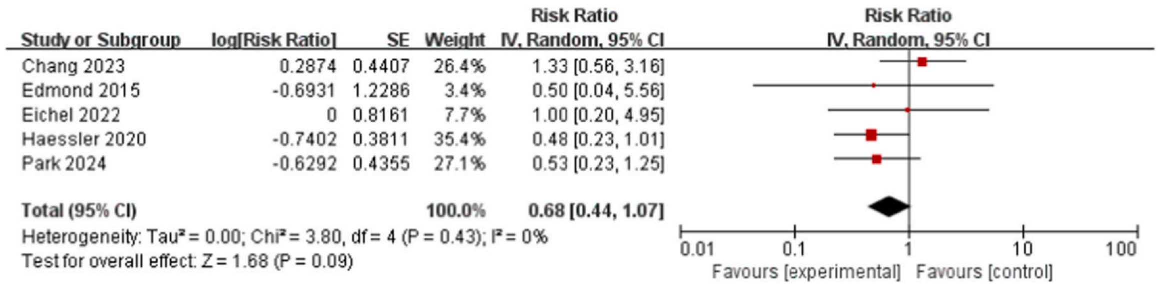


**Fig. 3.** Impact of stopping isolation on hospital-associated VRE bloodstream infection. CI, confidence interval; SE, standard error; VRE, vancomycin-resistant enterococci.

safety issues such as anxiety and depression among patients, a substantial increase in nursing costs, a reduction in the number of doctor and nurse visits, medication errors, falls, and pressure ulcers.[21] Besides, for nondeveloped countries, the number of single rooms is limited, so it is necessary to adjust the utilization rate of single rooms reasonably and reduce the unnecessary use of single rooms in order to reserve medical resources for patients who need to use single rooms urgently.

A previous study discussed the impact of canceling CPs (such as the use of PPE) on the incidence of health care–associated infection in patients with VRE and Methicillin-resistant Staphylococcus aureus (MRSA) and found that there were decreased rates of hospital-associated VRE infection following stoppage of CPs (RR, 0.82; 95% CI, 0.72-0.94; $P = .005$),[8] which was consistent with the results of a meta-analysis of MDRO patients who stopped CPs in 2018 (RR, 0.82; 95% CI, 0.72-0.94; $P = .005$).[9] Most of the included studies defined CPs as the use of PPE,[33–35] and a few studies defined CPs as the use of PPE and isolation of VRE patients.[19,20] There was a lack of meta-analysis of the impact of isolation on the rate of hospital-associated VRE infection. Although this study included some studies on the effect of removing CPs (use of PPE and isolation) on VRE infection rates, 5 studies in this meta-analysis were published in 2022 and later. Several studies in this meta-analysis showed that the incidence of hospital-associated VRE colonization or infection increased in the short term after stopping isolation, but the incidence of hospital-associated VRE colonization or infection stabilized after the removal of isolation for a period of time.[16,17,20] Furthermore, based on the results of this systematic review and meta-analysis, there is evidence to support that canceling the single-room or cohort isolation of VRE patients will not affect the rates of hospital-associated VRE infection. This may be related to the fact that HH compliance was higher than 84% in most previous studies.[10,11,17,18] Further, the transmission mode of VRE is contact transmission and will not spread in the air through coughing or sneezing.[1] Meanwhile, a previous study analyzed the genetic similarity of fecal and blood isolates from VRE patients and found that their molecular epidemiology was mainly sporadic and that most patients harbored unique VRE strains.[36] Therefore, in the context of endemic or nonoutbreak settings, the hospital-associated VRE infection rate can be maintained at a low level.[10,16]

Some limitations of this study are difficult to avoid. This study is only looking at rates of infection and not transmission. Some of those health care–associated infection rates may be due to infection with one's own flora, not transmission, which may not be impacted by PPE and isolation. Furthermore, this study is not looking at whole-genome sequencing or clusters to confirm the impact of changing isolation practices and is not applicable to epidemic (such as outbreak) situations. Additionally, the limited number of studies in the meta-analysis may affect the reliability of the evidence obtained in this study. Moreover, the studies we included were mainly based on interrupted time series analysis, which made it difficult to control other events unchanged (such as antimicrobial drug management, personnel changes, and infection prevention policies) that may affect the outcome before and after stopping isolation. Due to the lack of data on some confounding factors before and after removing isolation in previous studies, it is difficult to conduct subgroup analysis on HH, chlorhexidine bathing, and environmental disinfection practices in order to explore the influence of various confounding factors on the research results.

## CONCLUSIONS

In conclusion, this systematic review and meta-analysis suggested that in the context of endemic or nonoutbreak settings, discontinuation of isolation for VRE patients has not been associated with an increased rate of HA-VRE infections, which may be related to the hospital maintaining an adherence to HH practices of at least 84%, implementing daily CHG bathing, and adhering to a robust protocol for environmental disinfection practices. However, only a limited number of studies meet the inclusion criteria. Thus, more countries need to participate in and work on multicenter studies with complete confounding factor data and longer follow-up time to confirm this finding.

## APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at doi:10.1016/j.ajic.2024.07.018.

## References

1. Centers for Disease Control and Prevention. *Antibiotics Resistance Threats in the United States 2019 VRE.* U.S. Department of Health and Human Services, CDC; 2019.
2. Eichel VM, Last K, Brühwasser C, et al. Epidemiology and outcomes of vancomycin-resistant enterococcus infections: a systematic review and meta-analysis. *J Hosp Infect.* 2023;141:119–128.
3. Willems R, van Dijk K, Vehreschild M, et al. Incidence of infection with multidrug-resistant Gram-negative bacteria and vancomycin-resistant enterococci in carriers: a systematic review and meta-regression analysis. *Lancet Infect Dis.* 2023;23:719–731.
4. Yang Q, Wu A, Hu B, et al. Expert consensus on strategies for the prevention and control of spread of clinically important antimicrobial-resistant organisms. *Chin J Inlect Control.* 2021;20:1–14.
5. Siegel JD, Rhinehart E, Jackson M, Chiarello L, Healthcare Infection Control Practice Advisory Committee. Management of multidrug-resistant organisms in health care settings, 2006. *Am J Infect Control.* 2007;35:S165e93.
6. Zeng M, Xia J, Zong Z, et al. Guidelines for the diagnosis, treatment, prevention and control of infections caused by carbapenem-resistant gram-negative bacilli. *J Microbiol Immunol Infect.* 2023;56:653–671.
7. Morgan DJ, Wenzel RP, Bearman G. Contact precautions for endemic MRSA and VRE: time to retire legal mandates. *JAMA.* 2017;318:329e30.
8. Kleyman R, Cupril-Nilson S, Robinson K, et al. Does the removal of contact precautions for MRSA and VRE infected patients change health care-associated infection rate?: A systematic review and meta-analysis. *Am J Infect Control.* 2021;49:784–791.
9. Marra AR, Edmond MB, Schweizer ML, et al. Discontinuing contact precautions for multidrug-resistant organisms: a systematic literature review and meta-analysis. *Am J Infect Control.* 2018;46:333–340.

10. Park S, Bae S, Kim EO, et al. The impact of discontinuing single-room isolation of patients with vancomycin-resistant enterococci: a quasi-experimental single-centre study in South Korea. *J Hosp Infect.* 2024;147:77–82.
11. Chang E, Im D, Lee HY, et al. Impact of discontinuing isolation in a private room for patients infected or colonized with vancomycin-resistant enterococci (VRE) on the incidence of healthcare-associated VRE bacteraemia in a hospital with a predominantly shared-room setting. *J Hosp Infect.* 2023;132:1–7.
12. Popiel KY, Miller MA. Evaluation of vancomycin-Resistant Enterococci (VRE)-associated morbidity following relaxation of VRE screening and isolation precautions in a tertiary care hospital. *Infect Control Hosp Epidemiol.* 2014;35:818–825.
13. Hansen S, Klein K, Nymark A, et al. Vancomycin-resistant *Enterococcus faecium*: impact of ending screening and isolation in a Danish University hospital. *J Hosp Infect.* 2024;146:82–92.
14. Biehl LM, Higgins PG, Stemler J, et al. Impact of single-room contact precautions on acquisition and transmission of vancomycin-resistant enterococci on haematological and oncological wards, multicentre cohort-study, Germany, January-December 2016. *Euro Surveill.* 2022;27:2001876.
15. Kakimoto K, Nishiki S, Kaga Y, et al. Effectiveness of patient and staff cohorting to reduce the risk of vancomycin-resistant enterococcus (VRE) acquisition: a retrospective cohort study during a VRE outbreak in Japan. *J Hosp Infect.* 2023;134:35–42.
16. Eichel VM, Boutin S, Frank U, et al. Impact of discontinuing contact precautions and enforcement of basic hygiene measures on nosocomial vancomycin-resistant *Enterococcus faecium* transmission. *J Hosp Infect.* 2022;121:120–127.
17. Martin EM, Colaianne B, Bridge C, et al. Discontinuing MRSA and VRE contact precautions: defining hospital characteristics and infection prevention practices predicting safe de-escalation. *Infect Control Hosp Epidemiol.* 2022;43:1595–1602.
18. Haessler S, Martin EM, Scales ME, et al. Stopping the routine use of contact precautions for management of MRSA and VRE at three academic medical centers: an interrupted time series analysis. *Am J Infect Control.* 2020;48:1466–1473.
19. Edmond MB, Masroor N, Stevens MP, et al. The impact of discontinuing contact precautions for VRE and MRSA on device-associated infections. *Infect Control Hosp Epidemiol.* 2015;36:978–980.
20. Gandra S, Barysauskas CM, Mack DA, et al. Impact of contact precautions on falls, pressure ulcers and transmission of MRSA and VRE in hospitalized patients. *J Hosp Infect.* 2014;88:170–176.
21. Fregonese L, Currie K, Elliott L. Hospital patient experiences of contact isolation for antimicrobial resistant organisms in relation to health care–associated infections: a systematic review and narrative synthesis of the evidence. *Am J Infect Control.* 2023;51:1263–1271.
22. Aromataris E, Lockwood C, Porritt K, eds. *JBI Manual for Evidence Synthesis.* JBI; 2024.
23. Aboelela SW, Saiman L, Stone P, et al. Effectiveness of barrier precautions and surveillance cultures to control transmission of multidrug-resistant organisms: a systematic review of the literature. *Am J Infect Control.* 2006;34:484–494.
24. van der Kooi TII, Smid EA, Koek MBG, et al. The effect of an intervention bundle to prevent central venous catheter-related bloodstream infection in a national programme in the Netherlands. *J Hosp Infect.* 2023;131:194–202.
25. Wong V, Huang Y, Wei WI, et al. Approaches to multidrug-resistant organism prevention and control in long-term care facilities for older people: a systematic review and meta-analysis. *Antimicrob Resist Infect Control.* 2022;11:7.
26. Verdugo-Paiva F, Otaiza F, Roson-Rodríguez P, et al. Effects of screening strategies to detect carbapenem-resistant gram-negative bacteria: a systematic review. *Am J Infect Control.* 2022;50:1381–1388.
27. Tien KL, Wang JT, Sheng WH, et al. Chlorhexidine bathing to prevent healthcare-associated vancomycin-resistant Enterococcus infections: a cluster quasi-experimental controlled study at intensive care units. *J Formos Med Assoc.* 2021;120:1014–1021.
28. Messler S, Klare I, Wappler F, et al. Reduction of nosocomial bloodstream infections and nosocomial vancomycin-resistant *Enterococcus faecium* on an intensive care unit after introduction of antiseptic octenidine-based bathing. *J Hosp Infect.* 2019;101:264–271.
29. Sottani C, Barraza GF, Frigerio F, et al. Effectiveness of a combined UV-C and ozone treatment in reducing healthcare-associated infections in hospital facilities. *J Hosp Infect.* 2023;139:207–216.
30. Vaivoothpinyo S, Sathitakorn O, Jantarathaneewat K, et al. The impact of environmental cleaning protocol featuring PX-UV in reducing the incidence of multidrug-resistant gram-negative healthcare-associated infection and colonization in intensive care units in Thailand. *Infect Control Hosp Epidemiol.* 2024;45:684–687.
31. Blane B, Coll F, Raven K, et al. Impact of a new hospital with close to 100% single-occupancy rooms on environmental contamination and incidence of vancomycin-resistant *Enterococcus faecium* colonization or infection: a genomic surveillance study. *J Hosp Infect.* 2023;139:192–200.
32. van der Schoor AS, Severin JA, Klaassen C, et al. Environmental contamination with highly resistant microorganisms after relocating to a new hospital building with 100% single-occupancy rooms: a prospective observational before-and-after study with a three-year follow-up. *Int J Hyg Environ Health.* 2023;248:114106.
33. Bearman G, Abbas S, Masroor N, et al. Impact of discontinuing contact precautions for methicillin-resistant *Staphylococcus aureus* and Vancomycin-Resistant Enterococcus: an interrupted time series analysis. *Infect Control Hosp Epidemiol.* 2018;39:676–682.
34. Furuya EY, Cohen B, Jia H, Larson EL. Long-term impact of universal contact precautions on rates of multidrug-resistant organisms in ICUs: a comparative effectiveness study. *Infect Control Hosp Epidemiol.* 2018;39:534–540.
35. Rupp ME, Fitzgerald T, Hayes K, et al. Effect of cessation of contact isolation for endemic methicillin-resistant *Staphylococcus aureus* and Vancomycin-Resistant Enterococci. *Infect Control Hosp Epidemiol.* 2017;38:1005–1007.
36. Almyroudis NG, Osawa R, Samonis G, et al. Discontinuation of systematic surveillance and contact precautions for Vancomycin-Resistant Enterococcus (VRE) and its impact on the incidence of VRE faecium bacteremia in patients with hematologic malignancies. *Infect Control Hosp Epidemiol.* 2016;37:398–403.