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Major Article

# Discontinuing contact precautions for multidrug-resistant organisms: A systematic literature review and meta-analysis

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*Key Words:*
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***Background:*** Several single-center studies have suggested that eliminating contact precautions (CPs) for methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) control in nonoutbreak settings has no impact on infection rates. We performed a systematic literature review and meta-analysis on the impact of discontinuing contact precautions in the acute care setting.

***Methods:*** We searched PubMed, CINAHL, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, and Embase through December 2016 for studies evaluating discontinuation of contact precautions for multidrug-resistant organisms. We used random-effect models to obtain pooled risk ratio estimates. Heterogeneity was evaluated with $I^2$ estimation and the Cochran Q statistic. Pooled risk ratios for MRSA and VRE were assessed separately.

***Results:*** Fourteen studies met inclusion criteria and were included in the final review. Six studies discontinued CPs for both MRSA and VRE, 3 for MRSA only, 2 for VRE only, 2 for extended-spectrum β-lactamase–producing *Escherichia coli*, and 1 for *Clostridium difficile* infection. When study results were pooled, there was a trend toward reduction of MRSA infection after discontinuing CPs (pooled risk ratio, 0.84; 95% confidence interval, 0.70-1.02; $P = .07$) and a statistically significant reduction in VRE infection (pooled risk ratio, 0.82; 95% confidence interval, 0.72-0.94; $P = .005$).

***Conclusions:*** Discontinuation of CPs for MRSA and VRE has not been associated with increased infection rates.



## BACKGROUND

Contact precautions (CPs) were first recommended by the Centers for Disease Control and Prevention in 1970,[1] at a time when there was minimal surveillance for health care–associated infections (HAIs), few single-bed hospital rooms, very poor compliance with hand hygiene, no use of alcohol-based handrubs, no chlorhexidine bathing to decolonize patients, and no enhanced technology for environmental disinfection.[2,3] Over the ensuing decades, more knowledge has been acquired about strategic approaches to infection prevention. Despite the widespread use of CPs, there is little evidence to support effectiveness in the prevention of methicillin-resistant *Staphylococcus aureus* (MRSA) or vancomycin-resistant enterococci (VRE) infections in endemic settings.[4,5] In addition, questions have been raised regarding the impact of CPs on care delivery and patient safety.[6,7]

The objective of this study was to perform a systematic review of the literature and meta-analysis of studies that described hospitals' experience in discontinuing CPs for multidrug-resistant organisms, including MRSA, VRE, *Clostridium difficile*, and extended-spectrum β-lactamase–producing *Escherichia coli* (ESBL–*E coli*) in the acute care setting.

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## METHODS

### *Systematic literature review and inclusion and exclusion criteria*

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement[8] and to the Meta-Analysis of Observational Studies in Epidemiology.[9] Institutional review board approval was not required. Inclusion criteria for studies in this systematic review were as follows: original research articles; published in peer-reviewed, scientific journals; involved human inpatients; conducted in acute care settings that discontinued CPs for MRSA, VRE, *C difficile*, or ESBL–*E coli*; and controlled trial or quasi-experimental study design. The literature search was limited to the last 30 years (June 1985-December 2016) because the first reported discontinuation of CPs occurred in the 1990s. Editorials, correspondence, commentaries, and outbreak studies were excluded. Studies in which discontinuation of CPs was linked directly to MRSA or VRE microbiologic surveillance (ie, stopping CPs based on negative cultures for individual patients) were also excluded after careful review.

### *Search strategy*

We performed literature searches in PubMed, CINAHL, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Database of Abstracts of Reviews of Effects, Scopus (which includes Embase abstracts), and PsycINFO via PsycNET with the terms: (1) contact precautions: ("contact precaution" [MeSH Terms] OR "contact precautions" [MeSH Terms] OR "universal precaution" [MeSH Terms] OR "universal precautions" [MeSH Terms] OR "isolation precaution"[All Fields] OR "isolation precautions" [All Fields] OR "barrier precaution" [All Fields] OR "barrier precautions" [All Fields] OR "contact isolation" [All Fields] OR "contact isolations" [All Fields]; (2) MRSA: (MRSA [MeSH Terms] OR methicillin-resistant *Staphylococcus aureus* [MeSH Terms] OR methicillin AND resistant AND *Staphylococcus aureus* [MeSH Terms] OR cross infection AND cross AND infection [MeSH Terms]; (3) VRE: (VRE [MeSH Terms] OR vancomycin-resistant *Enterococcus* [MeSH Terms] OR vancomycin AND resistant AND *Enterococcus* [MeSH Terms]); (4) *Clostridium difficile* (*Clostridium difficile* [MeSH Terms] OR *C. difficile* (*C. difficile* [MeSH Terms] AND infection [MeSH Terms] AND colonization [MeSH Terms]; and (5) *Escherichia coli*: (*Escherichia coli* [MeSH Terms] OR ESBL [MeSH Terms] OR beta-lactamase [MeSH Terms] AND extended-spectrum beta-lactamase (extended-spectrum beta-lactamase [MeSH Terms] AND infection [MeSH Terms]. We reviewed the reference lists of retrieved articles to identify studies that were not identified from the preliminary literature searches.

When searched alone, the term "contact precautions" yielded 434 articles, "MRSA" yielded 18,009 articles, "VRE" yielded 2,385 articles, "*Clostridium difficile*" yielded 11,622 articles, and "extended-spectrum beta-lactamase producing *Escherichia coli*" yielded 547 articles. After applying exclusion criteria, we reviewed the full articles for 74 articles, and 14 studies met the inclusion criteria and were included in the systematic review (Fig 1).

### *Data abstraction and quality assessment*

Titles and abstracts of all articles were screened to assess whether they met inclusion criteria. The reviewers (A.R.M. and G.W.R.) abstracted data on study design, population and setting, interventions tested, and measurement of discontinuation for CPs. We used the scale used by Aboelela et al.[10] and Cohen et al.[11] to review publications regarding discontinuation of CPs. This tool has items regarding sample representativeness, bias and confounding, description of the intervention, outcomes and follow-up, and statistical analysis, which are each ranked 1-4, with 4 being the highest quality. Each reviewed article was assessed as to whether it addressed the aforementioned categories in a manner that was completely adequate; partially adequate; inadequate, not stated, or impossible to tell; or not applicable.[10,11] The authors (A.R.M. and G.W.R.) reviewed all inconsistent assessments, performed component quality analysis independently, and determined results by consensus.[12] For quasi-experimental studies we evaluated whether time series analysis was performed, the rationale for why randomization was not used, and other caveats of a quasi-experimental design.[13]

### *Statistical analysis*

To meta-analyze the extracted data, we calculated the natural log of the risk ratios and SEMs for MRSA and VRE studies independently. All the studies in the meta-analysis except Gandra et al[14] evaluated infections as the outcome, not colonization. We used random-effect models to obtain pooled risk ratio (pRR) estimates, using Microsoft Excel 2007 (Microsoft, Redmond, WA) and Cochrane RevMan version 5.2 (The Cochrane Collaboration, Copenhagen, Denmark). Heterogeneity between studies was evaluated using the $I^2$ statistic and the Cochran Q statistic. Publication bias was assessed by visually evaluating the symmetry of a funnel plot.

## RESULTS

### *Characteristics of included studies*

Fourteen studies met the inclusion criteria and were included in the final review (Table 1). All these studies were considered quasi-experimental studies. Twelve studies were nonrandomized quasi-experimental studies comparing infection rates pre- and postdiscontinuation of CPs.[14-25] Ninety-two percent (11/12) of these studies compared rates for specific microorganisms (MRSA, VRE, *C difficile*, or ESBL–*E coli*), and 1 compared device-associated HAI rates.[17] One study was a retrospective observational study[26] comparing 2 academic hospitals (CPs vs non-CPs), and another was a prospective observational study.[27]

Most of the studies included in our review were conducted in the United States (10 studies),[14-23] 2 studies were performed in Switzerland,[24,27] 1 was conducted in Canada,[25] and 1 was conducted in France.[26] Most of the studies discontinued CPs in the entire hospital (12 studies),[15-19,21,23-27] one study discontinued CPs in a leukemia, bone marrow transplant, and lymphoma service of a cancer institute,[20] and another study was specific to trauma patients at an academic medical center.[22] Many of the studies included in our review were conducted at academic medical centers (10 studies),[15-20,22,24-27] 3 studies were performed at community medical centers,[19,21,23] and 1 was performed at a cancer institute.[20]

Nine studies discontinued CPs for MRSA,[15-19,21-23] 8 studies discontinued CPs for VRE,[15-18,20,22,25] 2 studies discontinued CPs for ESBL–*E coli*,[24,26] and 1 study stopped CPs for *C difficile* infection[27] (except for hypervirulent strains or patients with stool incontinence). Among the 9 MRSA studies,[15-19,21-23] 6 also discontinued CPs for VRE,[15-18,22] and 3 studies stopped CPs only for MRSA.[15,21,23] Among 8 VRE studies, 6 also discontinued CPs for MRSA,[15-18,22] and 2 studies stopped CPs only for VRE.[20,25] The studies included in this review that discontinued CPs for *C difficile* (1 study)[27] and ESBL–*E coli* (2 studies)[24,26] stopped CPs only for the mentioned microorganisms, respectively.

The year that the discontinuation of CPs occurred ranged from 1993-2015. The longest study time was 10 years,[27] and the

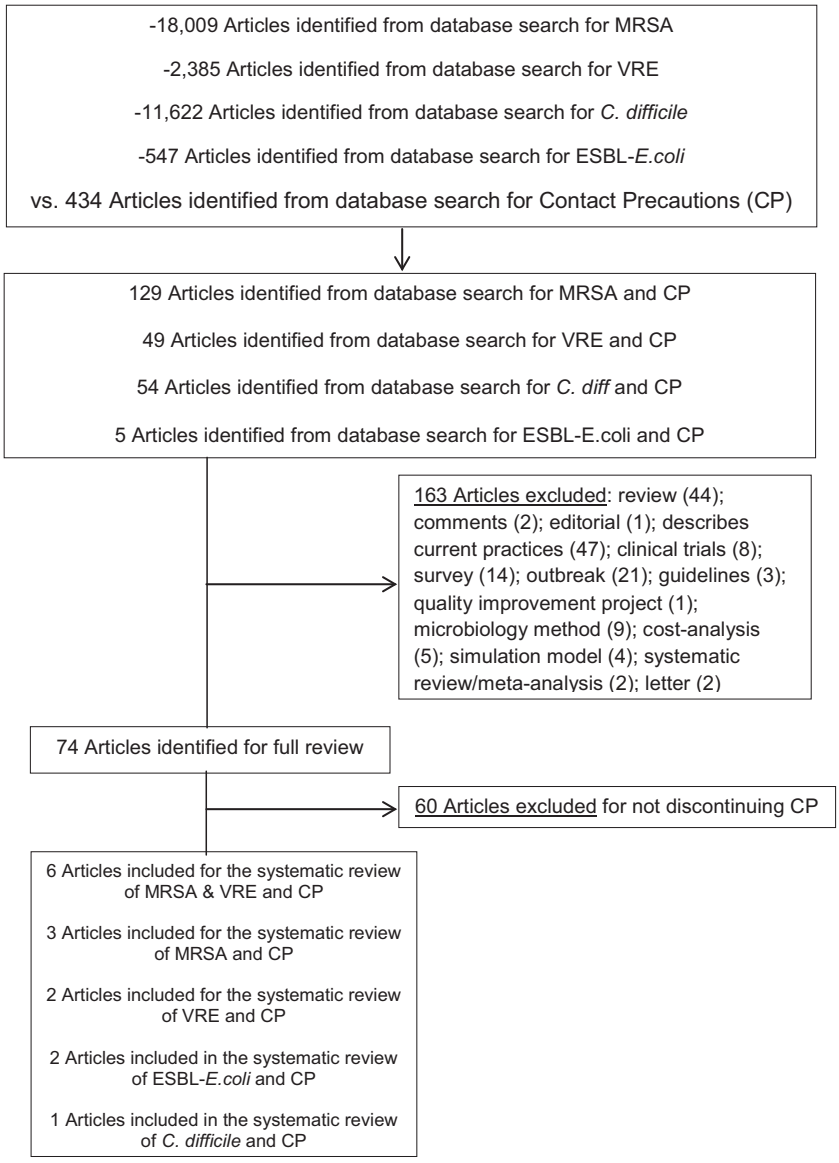


**Fig 1.** Literature search for articles on discontinuing CPs for MRSA, VRE, *Clostridium difficile*, or ESBL-*E coli*. *CP*, contact precautions; *ESBL-E coli*, extended-spectrum β-lactamase–producing *Escherichia coli*; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *VRE*, vancomycin-resistant enterococci.

shortest study duration was 1 year.[22] Nine studies reported compliance with an alternative intervention, such as hand hygiene compliance interventions, bare-below-the-elbows, or chlorhexidine bathing.[15,17-20,24-27]

Half of the studies did not perform active microbiologic surveillance for MRSA and VRE to determine colonization[14,18,21,22,24,26,27] (Table 1). Of the 9 MRSA studies, 7 performed active surveillance (77.8%). Of 8 VRE studies, 5 performed active surveillance (62.5%). Two studies[20,25] discontinued VRE microbiologic surveillance in the postintervention period (discontinuing CPs for VRE). Both of these studies measured only infections as the outcome, not colonization. Two studies performed molecular typing, one by pulsed-field gel electrophoresis[24] and another by polymerase chain reaction ribotyping for all isolates with a positive result for the presence of the binary toxin gene for *C difficile* to show that the strain shared identity with the strain of the index patient.[27] In both studies the transmission rates were similar to those observed when CPs were used.[24,27]

*Outcomes measures and follow-up*

When we considered the assessment quality of the reviewed articles (Appendix 1), more than half of the studies (9 studies) were considered completely adequate for reporting compliance rates of infection prevention process metrics (hand hygiene, environmental cleaning, and chlorhexidine bathing),[15,17-19,24-27] and 1 study reported compliance with bare-below-the-elbows.[17] Most of these studies (11 studies) had a clearly defined outcome.[15-18,20,21,24-27]

There were too few studies of *C difficile*[27] and ESBL–*E coli*[24,26] to pool results; however, the 2 ESBL–*E coli* studies were discordant (one showing no change; however, no rates per patient days were shown[26]); and one showing an increase in infection-colonization rates (0.41 to 1.87 per 1,000 patient days in hospital A and from 0.54 to 1.31 per 1,000 patient days at hospital B[20]). The *C difficile* study revealed a trend toward increased infection rates (from 2.8 per 10,000 patient days in 2004 to 4.3 per 10,000 patient days in 2013, $P = .013$) but a very low rate of transmission.[27]

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

| First author, year, location | Study design | Study setting (no. of beds) | Study period (y) | Pathogens for which CPs discontinued | Year CPs discontinued | Active microbiologic surveillance | Compliance with alternative interventions to CPs reported | Outcome (rates of infection) |
|---|---|---|---|---|---|---|---|---|
| Gandra, 2014,[14] Worcester, MA | QE (pre-post intervention comparison) | Entire academic medical center (781) | 2 | MRSA, VRE | 2010 | Yes (MRSA and VRE in adult ICUs and VRE in BMT unit) | No | No impact on MRSA or VRE acquisition rates (MRSA: 0.77 to 0.017 per 1,000 patient days; VRE: 1.39 to 0.016 per 1,000 patient days) |
| Edmond, 2015,[17] Richmond, VA | QE (pre-post intervention comparison) | Entire academic medical center (865) | 2.5 | MRSA, VRE | 2013 | No (except for MRSA in NICU) | Yes | No impact on MRSA or VRE device-associated HAI rates (MRSA: 15 to 12 per 1,000 device days; VRE: 22 to 17 per 1,000 device days) |
| Graman, 2015,[16] Rochester, NY | QE (pre-post intervention comparison) | Entire academic medical center (800) | 2.25 | MRSA, VRE | 2014 | Yes (only for preoperative MRSA screening) | No | No impact on MRSA HAI rate (MRSA: 3.56 to 3.56 per 10,000 patient days; VRE: no rates were shown) |
| Rupp, 2017,[18] Omaha, NE | QE (pre-post intervention comparison) | Entire academic medical center (800) | 2 | MRSA, VRE | 2015 | No | Yes | No impact on MRSA or VRE HAI rates (MRSA: 0.55 to 0.48 per 1,000 patient days; VRE: 0.45 to 0.32 per 1,000 patient days) |
| Almyroudis, 2016,[20] Buffalo, NY | QE (pre-post intervention comparison) | Leukemia, BMT and lymphoma service of a cancer institute (125) | 6 | VRE | 2011 | Discontinued VRE surveillance in the posttest | Yes | No impact on VRE BSI rate (VRE: 2.32 to 1.87 per 1,000 patient days) |
| Martin, 2016,[15] Los Angeles, CA | QE (pre-post intervention comparison) | A: academic medical center (540); B: community teaching hospital (265) | 2 | MRSA, VRE | 2014 | Yes | Yes | A: No impact on MRSA or VRE HAI rates; B: No impact on MRSA or VRE BSI rates (MRSA: 0.40 to 0.32 per 100 admissions; VRE: 0.48 to 0.40 per 100 admissions) |
| Deatherage, 2016,[19] Placerville, CA | QE (pre-post intervention comparison) | Entire community medical center (113) | 4 | MRSA (colonization, not infection) | 2014 | Yes (MRSA) | Yes | No impact on MRSA HAI rate (MRSA: 0.152 to 0.124 per 1,000 patient days) |
| Lemieux, 2016,[25] Ontario, Canada | QE (pre-post intervention comparison) | Four large academic hospitals (2,200) | 3.5 | VRE | 2012 | Discontinued VRE surveillance in the posttest | Yes | No impact on VRE HAI rate (VRE: no rates were shown, but it was shown the incidence rate ratio: 0.59; 95% CI, 0.24-1.47) |
| Watkins, 2014,[22] Austin, TX | QE (pre-post intervention comparison) | Trauma patients of an academic medical center (188) | 1 | MRSA, VRE | 2012 | No | No | No impact on MDRO HAI rate (MRSA: 2.05 to 2.47 per 1,000 admissions; VRE: no rates were shown) |
| Spence, 2012,[23] Kalispell, MT | QE (pre-post intervention comparison) | Entire community medical center (285) | 4 | MRSA | 2010 | Yes | No | No impact on MRSA HAI rate (MRSA: 0.049 to 0.086 per 1,000 acute care hospital days) |
| Fazal, 1996,[21] South Bronx, NY | QE (pre-post intervention comparison) | Entire community medical center (725) | 3.6 | MRSA | 1993 | No | No | No impact on MRSA colonization- infection rate (MRSA: no rates were shown) |
| Widmer, 2017,[27] Basel, Switzerland | QE (prospective observational study) | Entire academic medical center (735) | 10 | *Clostridium difficile* (except hypervirulent strains, incontinent patients) | 2004 | Yes (roommates) | Yes | Overall increase in *C difficile* rate, but extremely low transmission demonstrated via whole genome sequencing (2.8 per 10,000 patient days in 2004 to 4.3 per 10,000 patient days in 2013) |
| Tschudin-Sutter, 2016,[24] Basel, Switzerland | QE (pre-post intervention comparison) | A: academic medical center (735); B: academic-affiliated geriatric and rehabilitation center (320) | A: 2 B: 1.5 | ESBL–*E coli* | 2012 | Yes (roommates) | Yes | No impact on ESBL–*E coli* HAI- colonization rates (no rates were shown) |
| Zahar, 2015,[26] Paris, France | QE (retrospective study comparing 2 hospitals) | Entire academic medical center (800) | 5 | ESBL–*E coli* (except in NICU) | 2008 | Yes (ICU patients) | Yes | Increase in ESBL–*E coli* colonization-infection rate but no statistical testing performed (0.41 to 1.87 per 1,000 patient days in hospital A; and 0.54 to 1.31 per 1,000 patient days at hospital B) |

*BMT*, bone marrow transplant; *BSI*, bloodstream infection; *CI*, confidence interval; *CP*, contact precaution; *ESBL–E coli*, extended-spectrum β-lactamase–producing *Escherichia coli*; *HAI*, health care–associated infection; *ICU*, intensive care unit; *MDRO*, multidrug-resistant organism; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *NICU*, neonatal intensive care unit; *QE*, quasi-experimental; *VRE*, vancomycin-resistant enterococci.

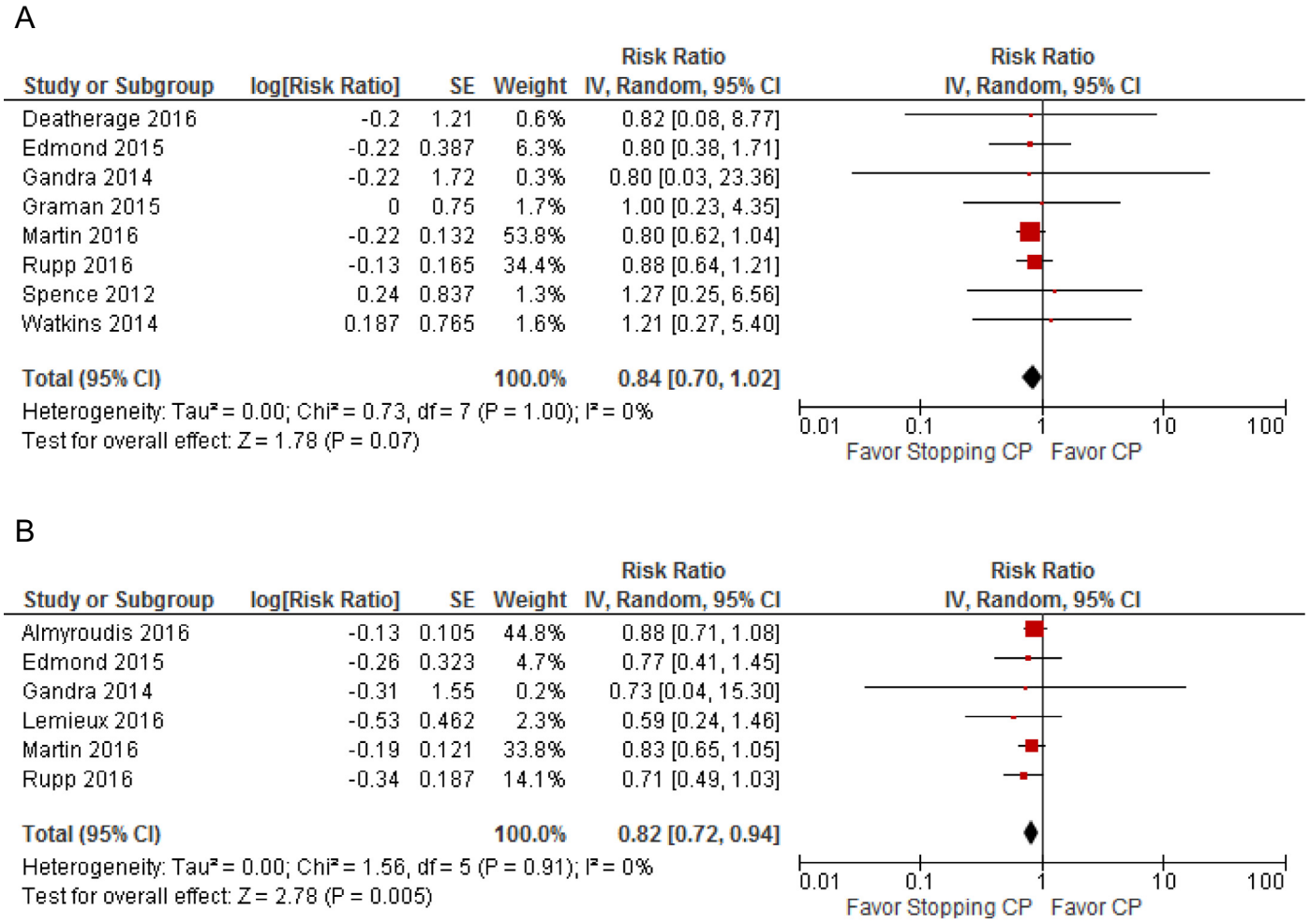


**Fig 2.** Forest plots of the associations between discontinuing CPs and (A) methicillin-resistant *Staphylococcus aureus* or (B) vancomycin-resistant enterococci infections. *CI*, confidence interval; *CP*, contact precautions; *IV*, inverse variance weighting; *SE*, SEM.

When the results of the MRSA and VRE studies were pooled, discontinuation of CPs for MRSA was associated with a nonsignificant reduction in MRSA infection rates (pRR, 0.84; 95% confidence interval [CI], 0.70-1.02; $P = .07$).[15-19,22,23] Discontinuation of CPs for VRE was associated with a statistically significant reduction in VRE infection rates (pRR, 0.82; 95% CI, 0.72-0.94; $P = .005$).[15,17,18,20,25] The results of both meta-analyses for MRSA and for VRE were homogeneous (MRSA: heterogeneity $P = 1.0$, $I^2 = 0\%$; VRE: heterogeneity $P = .91$, $I^2 = 0\%$) (Figs 2A and 2B). The MRSA study by Fazal et al[21] and the VRE study by Watkins et al[22] were not included in the meta-analysis because it was not possible to calculate the risk ratio with the available data. We also reanalyzed the data using only MRSA full articles, excluding 2 studies in abstract form (Graman et al[16] and Deatherage[19]). This resulted in no change in our findings (data not shown). There was little evidence of publication bias among MRSA and VRE studies as shown by the funnel plots in Figures 3A and 3B.

## DISCUSSION

This systematic review and meta-analysis found that discontinuing CPs for endemic MRSA and VRE across multiple health care facilities has not resulted in a detectable increase in MRSA or VRE infection rates. A growing number of U.S. hospitals are rethinking CP practices principally for patients colonized or infected with MRSA and VRE[28,29] and focusing resources on horizontal infection control strategies to prevent multidrug-resistant organisms,[2] strategies that include hand hygiene, bare-below-the-elbows, chlorhexidine bathing, care bundles, and environmental hygiene.[3] Our analysis demonstrated that these hospitals are not seeing immediate increases in infection rates, or indeed may be seeing reduced infection rates, without the use of gowns and gloves on entering patients' rooms.[29]

Different hypotheses could explain our results and should be explored in future studies. The first hypothesis is that CPs are not effective at preventing endemic MRSA and VRE infections; therefore, discontinuation of CPs does not change rates of these infections. Studies should explore whether this hypothesized lack of effectiveness is because of low health care worker compliance with CPs or low transmission of endemic infections as seen in the included *C difficile* study.[27] Alternatively, this difference could be explained by other effective interventions replacing CPs after CP discontinuation. One included study that described additional interventions stated they established 3 horizontal interventions (daily chlorhexidine bathing of all inpatients, a hand hygiene protocol, and a recommendation of a bare-below-the-elbows protocol) prior to CP discontinuation.[17] However, most of the included studies were unclear as to what interventions replaced CPs.

In our systematic literature review, all the included studies (14 studies) were nonrandomized quasi-experimental studies.[15-27]

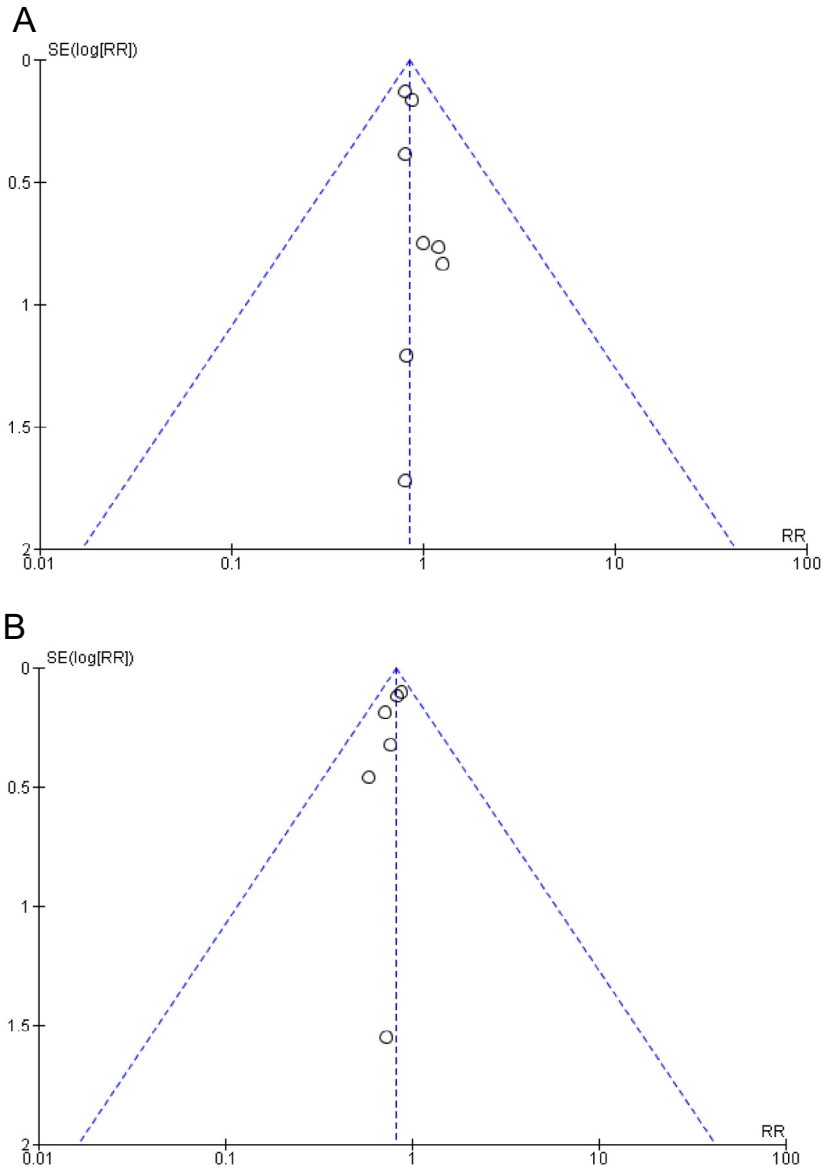


**Fig 3.** Funnel plots demonstrating the association between discontinuing contact precautions and (A) methicillin-resistant *Staphylococcus aureus* or (B) vancomycin-resistant enterococci infections. *RR*, risk ratio; *SE*, SEM.

Quasi-experimental studies attempt to demonstrate causality between an intervention and an outcome and encompass a broad range of nonrandomized intervention studies. These designs are frequently used when it is not logistically feasible or ethical to conduct a randomized controlled trial.[13] In our review, the outcome measures demonstrated no negative impact either for hospital infection rates, or for infection rates for the specific pathogen studied. Many hospitals discontinuing CPs for MRSA or VRE continued to perform active surveillance culturing for these pathogens.[14,15,17,19,20,23,25] Microbiologic screening in these studies was not used to discontinue CPs but to ensure that discontinuation of CPs was not associated with increasing transmission of these pathogens. Another interesting point is that hospitals that discontinued CPs for MRSA or VRE continued to apply CPs for *C difficile* and multidrug-resistant gram-negative rods.[14-18,22]

Our results are consistent with previously published controlled trials in which expanded use of CPs for carriers of MRSA and VRE was not associated with significantly reduced rates of MRSA and VRE infections.[5,30,31] Huskins et al, in a cluster randomized trial in 18 intensive care units (ICUs), found that universal MRSA and VRE screening (with CPs for carriers) did not reduce MRSA and VRE infection or acquisition beyond that of control ICUs.[5] This was despite the use of gloves or CPs for 92% of MRSA- or VRE-colonized ICU days (vs 38% on control ICUs).[5] Likewise, Huang et al found that universal use of decolonization strategies (CHG [chlorhexidine gluconate bathing] and mupirocin) was superior to MRSA screening and CPs at reducing MRSA clinical cultures and all-cause bloodstream infections in a 74-ICU cluster randomized trial.[30] Finally, Derde et al, reporting results from a 13-ICU cluster randomized trial, found no additional decrease in multidrug-resistant organism acquisition (including MRSA and VRE) associated with screening and CPs after an initial hand hygiene and CHG bathing intervention.[31]

The best current evidence to support use of CPs for multidrug-resistant organism control in the endemic setting is from the Benefits of Universal Gown and Glove (BUGG) use study, a cluster randomized trial in 20 ICUs that compared CPs for all patient encounters

with standard care.[4] The investigators found no difference between intervention and control units in the primary outcome of MRSA and VRE acquisition events combined. However, they found that the intervention units had a statistically significantly higher reduction in MRSA acquisition events (an incremental reduction of 2.98 events per 1,000 patient days).[4] The BUGG study intervention (universal CPs) goes well beyond that which we evaluated in this study, but the results help explain why the clinical impact of CPs use may be so small as to be difficult to detect even in a very large trial (or a meta-analysis). The BUGG study found a decrease of 1 MRSA acquisition for every 336 patient days of the universal CPs intervention. Given that there were 4 room entries per hour (96 per day) in the intervention arm, and given current best assumptions regarding the number of acquisition events because of transmission and the number of acquisitions that result in infection, >500,000 protected (gowned and gloved) encounters are likely to be necessary to prevent a single MRSA infection.[32] Therefore, even if CPs were effective in preventing MRSA transmission in the endemic setting, it is unlikely we will see a trial large enough to demonstrate an impact on an infection outcome.

Three recent systematic reviews on the effectiveness of CPs[11,29,33] have also concluded there were no high-quality data to support the use of CPs for endemic MRSA or VRE, and raised concern that there may be patient harm and unintended consequences.[29] Unintended consequences associated with CPs have been well documented in the literature.[6,7,33] These include decreased time spent with patients, delays in transfer of patients between inpatient units, excess attributable length of stay, increased readmission rates, and patients' perception of poor quality of care.[33-37] In one study,[27] the incidence of *C difficile* infection increased after discontinuing CPs; however, whole genome sequencing revealed that transmission was extremely low (n = 2) without CPs.

A limitation of our study was that we included many studies that were before-after quasi-experimental studies, which are subject to multiple biases.[13] Quasi-experimental study is the most common study design in the infection prevention literature.[29] However, study quality regarding compliance rates, bias and confounding, and failure to adjust for confounders and confirm equivalency between pre- and posttest groups is a limitation of this review, and it does not allow us to draw more conclusions from this evidence regardless of these studies' findings.[9,10] Finally, our meta-analysis was only as valid as the studies that contribute to the pRR. We agree that the results of this meta-analysis should be interpreted with caution; however, we observe that there were no results favoring CPs use for MRSA or VRE, and there was no evidence of publication bias in our results evaluated by funnel plots, acknowledging that funnel plot analysis is still a subjective analysis. Multicenter, carefully designed studies should be performed to evaluate the impact of discontinuation of CPs and determine which interventions (eg, chlorhexidine bathing, bare-below-the-elbows, improved hand hygiene compliance) could be used to replace CPs as an intervention to reduce rates of endemic MRSA and VRE infections.

In conclusion, we found no evidence that discontinuation of routine CPs for patients with MRSA or VRE has been associated with an increase in MRSA or VRE infection rates in acute care settings. These results are limited by the design of the studies included in our review and meta-analysis, and are not applicable to epidemic (eg, outbreak) situations. Nor are there sufficient studies to evaluate the impact of discontinuing CPs for resistant gram-negative pathogens or *C difficile*. We think discontinuation of CPs (as currently practiced) for MRSA and VRE can be safely accomplished, particularly in hospitals with a strong horizontal infection prevention strategy, including high levels of compliance with hand hygiene.

## References


1. Siegel JD, Rhinehart E, Jackson M, Chiarello L, The Healthcare Infection Control Practices Advisory Committee. Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. 2007. Available from: http://www.cdc.gov/hicpac/pdf/Isolation/Isolation2007.pdf. Accessed December 5, 2016.
2. Wenzel RP, Edmond MB. Infection control: the case for horizontal rather than vertical interventional programs. Int J Infect Dis 2010;14(Suppl):S3-5.
3. Edmond MB, Wenzel RP. Targeted decolonization to prevent ICU infections. N Engl J Med 2013;368:2614-5.
4. Harris AD, Pineles L, Belton B, Johnson JK, Shardell M, Loeb M, et al. Universal glove and gown use and acquisition of antibiotic-resistant bacteria in the ICU: a randomized trial. JAMA 2013;310:1571-80.
5. Huskins WC, Huckabee CM, O'Grady NP, Murray P, Kopetskie H, Zimmer L, et al. Intervention to reduce transmission of resistant bacteria in intensive care. New Engl J Med 2011;364:1407-18.
6. Morgan DJ, Kaye KS, Diekema DJ. Reconsidering isolation precautions for endemic methicillin-resistant Staphylococcus aureus and vancomycin-resistant Enterococcus. JAMA 2014;312:1395-6.
7. Morgan DJ, Diekema DJ, Sepkowitz K, Perencevich EN. Adverse outcomes associated with contact precautions: a review of the literature. Am J Infect Control 2009;37:85-93.
8. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6:e1000097.
9. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. JAMA 2000;283:2008-12.
10. Aboelela SW, Saiman L, Stone P, Lowy FD, Quiros D, Larson E. 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;34:484-94.
11. Cohen CC, Cohen B, Shang J. Effectiveness of contact precautions against multi-drug-resistant organism transmission in acute care: a systematic review of the literature. J Hosp Infect 2015;90:275-84.
12. Alderson PGS, Higgins JPT, editors. Assessment of study quality. Cochrane reviewer's handbook 4.2.3. Chichester, UK: John Wiley & Sons, Ltd; 2004.
13. Harris AD, Lautenbach E, Perencevich E. A systematic review of quasi-experimental study designs in the fields of infection control and antibiotic resistance. Clin Infect Dis 2005;41:77-82.
14. Gandra S, Barysauskas CM, Mack DA, Barton B, Finberg R, Ellison RT 3rd. Impact of contact precautions on falls, pressure ulcers and transmission of MRSA and VRE in hospitalized patients. J Hosp Infect 2014;88:170-6.
15. Martin EM, Russell D, Rubin Z, Humphries R, Grogan TR, Elashoff D, et al. Elimination of routine contact precautions for endemic methicillin-resistant Staphylococcus aureus and vancomycin-resistant Enterococcus: a retrospective quasi-experimental study. Infect Control Hosp Epidemiol 2016;37:1323-30.
16. Graman P, Shelly M, Pettis AM, Bronstein M, Greene L. Incidence of nosocomial Staphylococcus aureus infections after suspension of contact precautions (CP) for methicillin-resistant S. aureus. Open Forum Infectious Diseases 2015;2:1-66.
17. Edmond MB, Masroor N, Stevens MP, Ober J, Bearman G. The impact of discontinuing contact precautions for VRE and MRSA on device-associated infections. Infect Control Hosp Epidemiol 2015;36:978-80.
18. Rupp ME, Fitzgerald T, Hayes K, Van Schooneveld T, Hewlett A, Clevenger R, et al. Effect of cessation of contact isolation for endemic methicillin-resistant staphylococcus aureus and vancomycin-resistant enterococci. Infect Control Hosp Epidemiol 2017;38:1005-7.
19. Deatherage N. Impact of reduced isolation and contact precaution procedures on infection rates and facility costs at a non-profit acute care hospital. (9-255) (APIC 43rd Annual education conference & international meeting charlotte, NC June 11-13 2016). Am J Infect Control 2016;44:S101-2.
20. Almyroudis NG, Osawa R, Samonis G, Wetzler M, Wang S, McCarthy PL, 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.
21. Fazal BA, Telzak EE, Blum S, Turett GS, Petersen-Fitzpatrick FE, Lorian V. Trends in the prevalence of methicillin-resistant Staphylococcus aureus associated with discontinuation of an isolation policy. Infect Control Hosp Epidemiol 1996;17:372-4.
22. Watkins L, Ali S, Clark A, Brown CV. Transmission-based contact precautions for multidrug-resistant organisms in trauma patients: fewer days in isolation with no increase in hospital-associated infections. J Trauma Acute Care Surg 2014;77:960-3.
23. Spence MR, Dammel T, Courser S. Contact precautions for methicillin-resistant Staphylococcus aureus colonization: costly and unnecessary? Am J Infect Control 2012;40:535-8.
24. Tschudin-Sutter S, Frei R, Schwahn F, Tomic M, Conzelmann M, Stranden A, et al. Prospective validation of cessation of contact precautions for extended-spectrum β-lactamase-producing Escherichia coli. Emerg Infect Dis 2016;22:1094-7.
25. Lemieux C, Gardam M, Evans G, John M, Suh KN, vanWalraven C, et al. Longitudinal multicenter analysis of outcomes after cessation of control measures

for vancomycin-resistant enterococci. Infect Control Hosp Epidemiol 2017;38:24-30.
26. Zahar JR, Poirel L, Dupont C, Fortineau N, Nassif X, Nordmann P. About the usefulness of contact precautions for carriers of extended-spectrum beta-lactamase-producing Escherichia coli. BMC Infect Dis 2015;15:512.
27. Widmer AF, Frei R, Erb S, Stranden A, Kuijper EJ, Knestch CW, et al. Transmissibility of Clostridium difficile without contact isolation: results from a prospective observational study with 451 patients. Clin Infect Dis 2017;64:393-400.
28. Welsh J. Reconsidering contact precautions for MRSA and VRE. Am J Nurs 2015;115:14-5.
29. Morgan DJ, Murthy R, Munoz-Price LS, Barnden M, Camins BC, Johnston BL, et al. Reconsidering contact precautions for endemic methicillin-resistant Staphylococcus aureus and vancomycin-resistant Enterococcus. Infect Control Hosp Epidemiol 2015;36:1163-72.
30. Huang SS, Septimus E, Kleinman K, Moody J, Hickok J, Avery TR, et al. Targeted versus universal decolonization to prevent ICU infection. N Engl J Med 2013;368:2255-65.
31. Derde LP, Cooper BS, Goossens H, Malhotra-Kumar S, Wllems RJ, Gniadkowski M, et al. Interventions to reduce colonization and transmission of antimicrobial-resistant bacteria in intensive care units: an interrupted time series study and cluster randomized trial. Lancet Infect Dis 2014;14:31-9.
32. Morgan D, Wenzel R, Bearman G. Contact precautions for endemic MRSA and VRE. Time to retire legal mandates. 2017. Available from: http://haicontroversies.blogspot.com/2017/06/the-burden-of-contact-precautions.html Accessed August 9, 2017.
33. Kullar R, Vassalo A, Turkel S, Chopra T, Kayne KS, Dhar S. Degowning the controversies of contact precautions for methicillin-resistant Staphylococcus aureus: a review. Am J Infect Control 2016;44:97-103.
34. Shenoy ES, Lee H, Hou T, Ware W, Ryan EE, Hooper DC, et al. The impact of methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant Enterococcus (VRE) flags on hospital operations. Infect Control Hosp Epidemiol 2016;37:782-90.
35. Johnson DW, Schmidt UH, Bittner EA, Christensen B, Levi R, Pino RM. Delay of transfer from the intensive care unit: a prospective observational study of incidence, causes, and financial impact. Crit Care 2013;17:R128.
36. Karki S, Leder K, Cheng AC. Delays in accessing radiology in patients under contact precautions because of colonization with vancomycin-resistant enterococci. Am J Infect Control 2013;41:1141-2.
37. Tran K, Bell C, Stall N, Tomlinson G, McGeer A, Morris A, et al. The effect of hospital isolation precautions on patient outcomes and cost of care: a multi-site, retrospective, propensity score-matched cohort study. J Gen Intern Med 2017;32:262-8.

## APPENDIX 1. QUALITY ASSESSMENT SCORES FOR THE REVIEWED MANUSCRIPTS*

| Quality criterion | Gandra[14] | Edmond[17] | Graman[16] | Rupp[18] | Almyroudis[20] | Martin[15] | Deatherage[19] | Lemieux[25] | Watkins[22] | Spence[23] | Fazal[21] | Widmer[27] | Tschudin-Sutter[24] | Zahar[26] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Representativeness | | | | | | | | | | | | | | |
| Study population description | 4 | 3 | 2 | 2 | 4 | 4 | 2 | 4 | 4 | 3 | 2 | 4 | 4 | 4 |
| Inclusion and exclusion criteria | 4 | 3 | 2 | 3 | 4 | 4 | 2 | 4 | 3 | 3 | 2 | 4 | 4 | 4 |
| Location and setting description | 4 | 2 | 2 | 2 | 4 | 4 | 2 | 4 | 4 | 3 | 4 | 4 | 4 | 4 |
| Bias and confounding | | | | | | | | | | | | | | |
| Study population corresponded to larger population in all key factors | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Masking | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| How similar was the assessment of outcomes between groups | 4 | 4 | 1 | 4 | 4 | 4 | 1 | 4 | 4 | 1 | 1 | 4 | 4 | 4 |
| Involvement from author | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Accounted for confounding interventions | 2 | 2 | 2 | 2 | 3 | 4 | 2 | 4 | 2 | 2 | 2 | 4 | 4 | 4 |
| Compliance rates | 2 | 4 | 2 | 4 | 4 | 4 | 3 | 4 | 2 | 2 | 2 | 4 | 4 | 4 |
| Description of intervention | | | | | | | | | | | | | | |
| Replication possible given descriptions of intervention | 4 | 4 | 2 | 4 | 4 | 4 | 2 | 4 | 4 | 3 | 3 | 4 | 4 | 3 |
| Outcomes and follow-up | | | | | | | | | | | | | | |
| Outcome assessment procedure clearly defined | 4 | 4 | 3 | 4 | 4 | 4 | 2 | 4 | 3 | 4 | 3 | 4 | 4 | 4 |
| Groups equivalent in attrition, LOS, death, or patient days | 4 | 3 | 2 | 3 | 4 | 3 | 2 | 4 | 2 | 2 | 2 | 4 | 3 | 4 |
| Statistical analysis | | | | | | | | | | | | | | |
| Description and appropriateness of methods | 4 | 4 | 2 | 4 | 4 | 4 | 2 | 4 | 4 | 3 | 4 | 4 | 4 | 4 |
| Tested differences between groups and variability | 4 | 2 | 2 | 2 | 4 | 4 | 2 | 4 | 4 | 2 | 2 | 4 | 2 | 4 |

*1*, not applicable; *2*, inadequate, not stated; *3*, partially adequate; *4*, completely adequate; *LOS*, length of stay.