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Original article

Implementing quality improvement strategies to reduce healthcare-associated infections: A systematic review

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Background: Comprehensive incidence estimates indicate that 1.7 million healthcare-associated infections (HAIs) and 99,000 HAI-associated deaths occur in US hospitals. Preventing HAIs could save $25.0 to $31.5 billion. Identifying effective quality improvement (QI) strategies for promoting adherence to evidence-based preventive interventions could reduce infections.

Methods: We searched MEDLINE, CINAHL, and EMBASE from 2006-2012 for English-language articles with $\geq$ 100 patients that described an implementation strategy to increase adherence with evidence-based preventive interventions and that met study design criteria. One reviewer abstracted and appraised study quality, with verification by a second. QI strategies included audit and feedback; financial incentives, regulation, and policy; organizational change; patient education; provider education; and provider reminder systems.

Results: We evaluated data on HAIs from 30 articles reporting adherence and infection rates that accounted for confounding or secular trends. Many of the measures improved significantly, especially adherence. Results varied by QI strategy(s).

Conclusions: Moderate strength of evidence supports improvement in adherence and infection rates when audit and feedback plus provider reminder systems or audit and feedback alone is added to organizational change and provider education. Strength of evidence is low when provider reminder systems alone are added to organizational change and provider education. There were no studies on HAIs in nonhospital settings that met the selection criteria.

Healthcare-associated infections (HAIs) are a major patient safety problem. The Centers for Disease Control and Prevention estimate 1.7 million HAIs and 99,000 HAI-associated deaths in hospitals during 2002. The 4 largest categories were responsible for >80% of reported HAIs: catheter-associated urinary tract infections (CAUTI) (32%), surgical site infections (SSI) (22%), ventilator-associated pneumonia (VAP) (15%), and central line-associated bloodstream infections (CLABSI) (14%).[1] Rates of some HAIs have declined in recent years, including decreases of 33% in CLABSI and 10% in SSIs since 2006-2008, and a 7% decrease in CAUTI since 2009; VAP trends were not reported.[2] Preventing 70% of HAIs is projected to save $25.0 billion to $31.5 billion.[3]

Considerable progress has been made in identifying evidence-based, preventive interventions to reduce HAIs, including those by the US Healthcare Infection Control Practices Advisory Committee, a federal advisory committee; the Society for Healthcare Epidemiology of America; and the Infectious Diseases Society of America.[4-7] Although evidence is available on how to reduce infections, less is known on how to spur adoption of these interventions, which is the subject of our article.

Our systematic review addresses which quality improvement (QI) strategies raise adherence to evidence-based preventive interventions to reduce HAIs. It builds on a prior 2007 Agency for Healthcare Research and Quality (AHRQ) Evidence Report.[8]

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METHODS

A search was run using MEDLINE, CINAHL, and EMBASE for articles published between January 2006 and January 2012. We also screened bibliographies and Web sites of organizations involved in QI, and made special efforts to identify research in nonhospital settings. This article is based on a report prepared for AHRQ in 2012 that provides additional details.[9]

One reviewer screened titles and abstracts for full-text retrieval and a second reviewer checked articles deemed uncertain. Other reviewers screened a random sample of about 3% of excluded titles and abstracts and found none eligible for full-text review. Reviewers were supervised using an initial training set. A single reviewer abstracted full-text articles, with data verification by a second reviewer. Articles were included if the study described an implementation strategy to increase adherence with ≥ 1 of the evidence-based preventive interventions. The specific preventive interventions to reduce infections used in the study selection process were chosen and amended from recommendations with a grade of 1A or 1B in the Healthcare Infection Control Practices Advisory Committee guidelines (see http://www.cdc.gov/hicpac/pubs.html) or with a grade of A-I or A-II in the *Compendium of Strategies to Prevent Healthcare-Associated Infections in Acute Care Hospitals*.[4-7] An example of the interventions is to disinfect environmental surfaces to prevent SSI. The combined baseline and postintervention sample size of patients at risk of infection had to be ≥ 100. Articles had to use an experimental design with a control group or a quasiexperimental design with statistical analysis that adjusted for confounding and/or secular trend and compared baseline and postintervention results for ≥ 1 outcomes.

Study quality appraisals were performed by dual independent review, with resolution by a third reviewer, when necessary. The criteria to evaluate study quality were:

1. Which study design was used?
2. Were baseline and postintervention adherence or infection rates each reported and analyzed statistically?
3. Was the statistical analysis adequate? Were potential confounders (eg, baseline patient characteristics) assessed? Were potential confounders controlled for in the analysis? Was an interrupted time series analysis used when appropriate?
4. Was the intervention independent of contemporaneous QI improvement efforts?
5. Did the follow-up period last ≥ 1 year?

Study design determined the initial quality classification of higher, medium, or lower. The terms *higher* and *lower* were used to indicate the relative ranking of quality in this report because most of the studies were quasiexperimental; individual-level randomized controlled trials (RCTs) generally are not appropriate for this application. The importance of design considerations in QI studies is described in the appendix online. Controlled trials were assigned higher quality and included individual RCTs, cluster RCTs, controlled interrupted time series, and controlled before–after studies. Interrupted time series analyses were assigned a quality of medium and simple before–after studies that adjust statistically for confounding, a lower quality. For each study, criteria 2 through 5 above were assigned a plus, minus, or uncertain. Any study receiving ≥ 2 minuses was moved to the next lower quality rating.

QI strategies were grouped into the following categories: provider education, patient education, audit and feedback, provider reminders, organizational change, financial or regulatory incentives for patients or clinicians, or a combination.[8] To develop a workable classification of QI strategy combinations, we hypothesized that organizational change and provider education constitute base strategies. Face validity is the initial rationale because 90% of the included studies used at least 1 of these strategies. In practical terms, little distinction could be made between those studies that did and did not use these 2 strategies. It is difficult to imagine the implementation of any QI effort without at least some level of these strategies.

The studies examined in this article evaluated the influence of a bundle of strategies. It was not possible to disentangle the effect of a single strategy from others in the same bundle because of spillover and interaction effects. Therefore, the bundles were grouped into a manageable set of categories (eg, base strategies plus audit and feedback) and analyzed as distinct entities.

Each type of HAI was analyzed separately, and then the results were compared across HAIs. The analyses of individual HAIs are found in the AHRQ report,[9] whereas the findings common across all HAIs are presented in this article. The articles included in our review differed in study design, outcomes, QI strategies, preventive interventions, context, measurement of adherence, and other factors. Quantitative analyses were not feasible, so the studies were synthesized qualitatively.

The strongest evidence of causality would be provided by both adherence and infection rates, to observe a potentially causal link between implementation of specific QI strategies and fewer infections. If adherence improved significantly while the change in infections was not significant, this could be due to weakness of the link between the preventive intervention and infection rate, insufficient power to detect a statistically significant change in infections, or other confounding factors. Studies reported adherence rates more frequently than infectious outcomes.

The overall strength of evidence grade was determined in accordance with the AHRQ Methods Guide[10] based on the GRADE Working Group's recommendations.[11] This system addresses four domains: risk of bias, consistency, directness, and precision. The strength of evidence consists of 4 categories. Each reflects the researchers' confidence that the evidence indicates the true effect, as well as the likelihood that further evidence would alter the confidence in this estimate of effect: high (change unlikely), moderate (confidence and estimate of effect may change), low (change in confidence and estimate of effect likely), and insufficient (estimate of effect not possible).

Because of the diversity in outcomes and their measurement across studies, we used a qualitative approach to determine precision, based on the following statement: "A precise estimate should enable decision makers to draw conclusions about whether one treatment is, clinically speaking, inferior, equivalent (neither inferior nor superior), or superior to another."[11] Specific outcomes and comparisons were rated. The GRADE rating was reached through consensus among the investigators.

RESULTS

The literature review yielded 8,362 abstracts. One hundred forty-nine articles met the initial selection criteria (see Appendix 1). This article focuses on the 26 articles that reported both adherence and infections. Most of the studies had quasiexperimental designs. Two of these studies reported on 2 infections and 1 reported on 3 infections, so the 26 articles yielded 30 studies. Hereafter, each infection is treated as a separate study.

Analyzing the influence of QI strategies is complicated by the fact that all but 3 articles[12-14] used ≥ 1 strategy, with 11 different combinations. Therefore, we grouped QI strategies together, an approach that mirrors common practice and may yield practical insights. Within each study, the intervention period was usually compared with a period of no intervention (usual care). Four studies compared the effect of the intervention to a low intensity