

Invasive Surgical Site Infections can be Risk-Adjusted with NNIS Risk Index

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Introduction

Publicly reporting rates of surgical site infections (SSIs) is laudable.

Theoretically, public reporting of rates of SSI can empower consumers to make informed decisions and, thus, is supposed to stimulate hospitals to improve overall health care quality. The actual implementation of and methods for public reporting, however, are unresolved and contentious issues.

Most involved in these controversies agree that CDC definitions should be used to identify SSIs.¹ Furthermore, most epidemiologists agree that some measure should be used to adjust for differences in the case-mix of operative populations to ensure that intra-hospital comparisons are more meaningful.^{2,3} Indeed, public reporting of crude, unadjusted rates for inter-hospital comparisons would lead to misleading conclusions regarding the SSI risk associated with specific institutions and surgeons.⁴ The National Nosocomial Infection Surveillance System (NNIS, now the National Health Safety Network or NHSN) risk index is a logical choice for risk-adjustment of publicly reported rates of SSI as it is a widely used, operation-specific, prospectively applied and validated method for risk adjustment.^{5,6}

The CDC definitions for SSI include three specific subtypes of infection: superficial-incisional, deep-incisional, and organ/space {REF}. Collectively, deep incisional and organ/space infections are known as “invasive” SSIs. The specific

categories of SSI used for public reporting, however, remain controversial. The diagnosis of superficial-incisional SSIs has lower sensitivity than invasive SSIs [Yokoe EID 2004]; furthermore, superficial-incisional SSIs often do not require re-hospitalization and are instead frequently diagnosed in the outpatient setting during post-discharge surveillance (Petrosillo BMC Inf Dis 2008). In contrast, invasive SSIs are serious infections that typically require rehospitalization, return to the operating room, and intravenous antibiotic therapy. Finally, some hospitals with high surgical volume only perform surveillance on invasive SSIs. As a result of these issues, some groups have recommended that external (public) reporting of rates of SSI be limited to invasive infections, thereby excluding superficial-incisional SSIs [www.qualityforum.org].

The NNIS risk index, however, was validated using all categories of SSI. In fact, 47% of SSIs included in the derivation of the NNIS risk index were categorized as superficial-incisional.⁷ Thus, it is unknown if the NNIS risk index can be applied to SSIs exclusively categorized as invasive.

If publicly reported rates of SSI are limited to invasive SSIs, it is imperative to have a valid method for risk-stratification to facilitate comparisons of rates among hospitals and to make these comparisons more meaningful. Furthermore, a validated risk-adjustment method would be useful for hospitals internal benchmarking in hospitals that only perform surveillance for invasive SSIs. The purpose of this study was to examine the validity of the NNIS risk index in predicting only invasive SSIs in a large cohort of hospitals.

Methods

We reviewed surgical procedures performed at 24 hospitals from January 1, 2005 through June 30, 2007. All hospitals were community hospitals located throughout the southeastern US (median bed size=210, range= 102-450) and were members of the Duke Infection Control Outreach Network (DICON). SSIs were prospectively identified at these study hospitals by trained ICPs using standard CDC criteria⁸ and identical surveillance methods.^{9,10} Surveillance was performed on all surgical procedures with a NNIS code and was performed to identify all categories of SSI.

The variables for the NNIS risk index (operation duration, American Society of Anesthesiology (ASA) Score, and wound class) were collected prospectively and the NNIS risk index was subsequently calculated for all procedures performed during the study period. We determined overall rates of SSI stratified by NNIS risk index and procedure-specific rates of SSI stratified by NNIS risk index (RI) for the following procedures: cardiothoracic (including coronary artery bypass grafts and cardiac surgery) procedures (RI 0, 1, or 2-3), colon procedures (RI 0, 1, 2, 3), abdominal hysterectomy (RI 0, 1, or 2-3), insertion of hip prosthesis (RI 0, 1, or 2-3), insertion of knee prosthesis (RI 0, 1, or 2-3), and vascular (including aortic aneurysm repair, carotid endarterectomy, and peripheral vascular bypass) procedures (RI 0, 1, or 2-3). These risk index groupings are in keeping with methods used and reported by NNIS.⁶ These specific procedures were chosen for analysis as they have been included in national quality improvement initiatives such as the Surgical Care Improvement Project (SCIP) [REF] and, thus, will likely be targets for public reporting.

Data were maintained in Access databases and analyzed using SAS statistical software (v9.1, Cary, NC, USA). Rates of SSI were calculated as follows: number of

SSIs/number of procedures x 100 = rate of SSI/100 procedures. The Goodman-Kruskal (gamma or G) statistic and 95% confidence intervals (CI) were used to determine correlation. The G statistic is a numeric value between -1 and +1. In general, higher G statistics suggest closer correlation. P-values ≤ 0.05 were determined to be statistically significant.

Results

In total, 2,257 SSIs were identified following 189,288 procedures performed at the 24 study hospitals during the 30 month period (overall rate of SSI = 1.19/100 procedures); 1,164 (51.6%) were superficial-incisional (rate of superficial-incisional SSI = 0.61/100 procedures) and 1,093 (48.4%) were invasive (rate of invasive SSI = 0.58/100 procedures). The overall rate of invasive SSI increased in a step-wise fashion as the NNIS risk index score increased (Figure 1). Increasing NNIS risk index score was highly correlated with increasing risk of SSI ($G=0.51$ [95% CI 0.48-0.55]; $p<0.0001$).

Procedure-specific SSIs were analyzed for six procedures: 119 SSIs were identified following 7,032 abdominal hysterectomies, 45 (38%) were invasive SSIs; 144 SSIs were identified following 5,318 cardiothoracic procedures, 63 (44%) were invasive SSIs; 284 SSIs were identified following 5,144 colon procedures, 139 (49%) were invasive SSIs; 105 SSIs were identified following 6,639 hip prosthesis insertions, 63 (60%) were invasive SSIs; 120 SSIs were identified following 9,658 knee prosthesis insertions, 73 (61%) were invasive SSIs; and 147 SSIs were identified following 6,575 vascular procedures, 55 (37%) were invasive. Procedure-specific rates of invasive SSI were determined for all six procedures (Table 1).

Similar trends were seen in each procedure after stratifying rates of invasive SSI by NNIS risk index. As the NNIS risk index score increased, the rates of invasive SSI increased in a step-wise fashion for each procedure (Figure 2). Procedure-specific rates of invasive SSI were significantly correlated with increasing NNIS risk index scores, as the p-values for each G statistic were <0.05 .

Discussion

Public disclosure of rates of healthcare-associated infections (HAI) is controversial and, despite its unclear benefit, appears to be inevitable. In fact, over 40 states had laws in place or on-going legislation regarding public reporting of HAIs as of the end of 2007 [APIC website]. Surgical site infections are a common target for these laws, because of the frequency with which surgeries and SSIs occur annually, because of the significant adverse impact of SSI on clinical outcomes [REFS], and because of existence and acceptance of established SSI definitions and categorizations. The exact methods that will be used for publicly reporting rates of SSIs remain unclear. In particular, the types of SSIs to report and the optimal method for risk-adjustment remain unknown.

Our large, multi-center cohort study is the first to examine the use of the NNIS risk index as a method for risk-stratification among SSIs exclusively labeled as invasive. After reviewing 189,288 surgical procedures, we determined that increasing NNIS risk index scores were significantly correlated with increasing rates of invasive SSI for abdominal hysterectomies, cardiothoracic procedures, colon procedures, insertion of hip prostheses, insertion of knee prostheses, and vascular procedures. Thus, we believe that

the NNIS risk index is a valid method for risk-adjustment of invasive SSIs in our hospital cohort.

Limiting surveillance to invasive SSIs will remove a large number of infections. In fact, data from the NNIS system suggests that approximately 50% of diagnosed SSIs are superficial-incisional [Gaynes CID 2001]. A large portion of superficial-incisional SSIs, however, are diagnosed during the post-discharge period. Unfortunately, no specific recommendations are available regarding the best method for post-discharge surveillance (Mangram CDC guidelines). As a result, different hospitals use different methods for performing post-discharge surveillance and some do not perform post-discharge surveillance at all. In fact, a recent systematic review of methods for post-discharge surveillance concluded that existing research has not identified a valid and reliable method (Petherick BMC Inf Dis 2006). Hospitals that do perform rigorous post-discharge surveillance are certain to find higher numbers of SSIs than hospitals that do not (Barnes AJIC 2006 34; 669). For example, rates of SSI in the Netherlands were much higher than rates of SSI in Germany when all SSIs were evaluated, but this difference was much less when only invasive SSIs were analyzed (Mannien JHI 2007; 66, 224). As a result of these issues, the Healthcare-Associated Infection Working Group of the Joint Public Policy Committee has recommended that surveillance for SSI only be performed on hospitalized patients (either during index hospitalization or readmission) [REF-web resource].

Not all authors agree, however, that the NNIS risk index is the best method to risk-stratify all surgical procedures. For example, several studies have shown that the NNIS risk index does not necessarily perform well for cardiothoracic procedures and, as

a result, proposed modifications that improved the predictive ability of the risk score (Friedman; Roy M et al. *Infect Control Hosp Epidemiol* 2000; 21:186-190.; Russo PL *Infect Control Hosp Epidemiol* 2002; 23:372-376; Paul J Thor *Cardiovasc Surg* 2007). Other authors have employed or recommended other methods for risk stratification including risk factor models developed at individual locations (Clements JHI 2007; Geubbels ICHE 2006; Brandt ICHE 2004), the standardized infection ratio (gaynes cid 2001), and the chronic disease score [Batista ICHE 06;27:802] to overcome the shortcomings of the NNIS risk index.

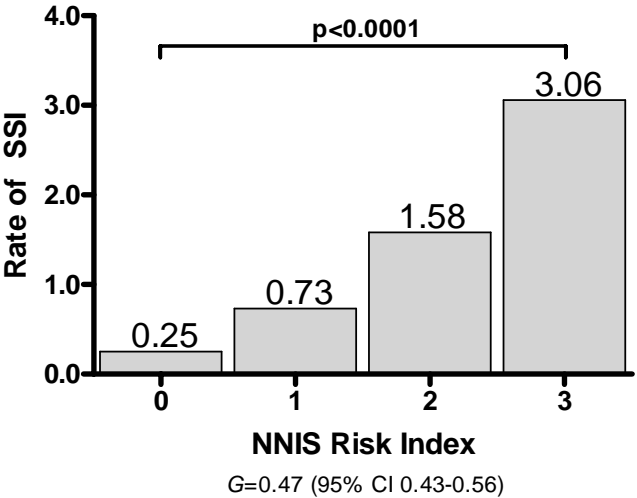
In fact, Gaynes et al. acknowledge the deficiencies of the NNIS risk index, commenting that “additional important risk factors for specific procedures need to be identified and incorporated” into an improved index. While several important risk factors have been identified in the studies referenced above (e.g., body mass index, diabetes mellitus, and the duration of pre-operative hospital stay), no consensus has been reached about which and how many of these variables should be included. Furthermore, it is our experience that many hospital surgical databases are not sophisticated enough to include specific patient co-morbidities, particularly in small community hospitals. Thus, to date, the NNIS risk index remains the most widely-used and simplest method available.

Our study has limitations. First, it may be limited by misclassification bias regarding the diagnosis of SSI. Our surveillance methods, however, were uniform across all study hospitals and have been previously validated [REF]. Furthermore, given the strong statistical associations between increasing risk index score and risk of SSI for most procedures, it seems unlikely that the misclassification of a few SSIs would change our results. Also, our study was performed exclusively at community hospitals in the US.

Our findings may not therefore be generalizable to academically-affiliated hospitals, hospitals in other countries, or to all healthcare settings. Since the majority of healthcare in the US is provided in community hospitals, our cohort of community hospitals might be viewed as study strength as well.

In summary, controversies still exist regarding the utility and methods for public reporting of rates of HAI. Rates of SSI require risk-adjustment to optimize intra-hospital comparisons. Based on the results of our study, we believe the NNIS risk index is a reasonable method for the risk-stratification of invasive SSIs for many commonly performed procedures

Figure 1. Rates of surgical site infection (SSI) stratified by National Nosocomial Infection Surveillance System (NNIS) risk index in 189,288 surgical procedures



Footnote: Invasive SSI includes deep incisional and organ/space infections.

G = gamma statistic; CI = confidence interval

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Table 1. Procedure-specific rates of invasive surgical site infection (SSI) for six selected procedures

Procedure	No. of Hospitals in Cohort	No. of Invasive SSIs/ No. of procedures	Rate of Invasive SSI/ 100 procedures
Abdominal hysterectomy	24	45/7032	0.64
Cardiothoracic	18	63/5318	1.18
Colon	24	139/5144	2.70
Insertion of hip prosthesis	24	63/6639	0.94
Insertion of knee prosthesis	24	73/9658	0.76
Vascular procedure	22	55/6575	0.84

Figure 2. Procedure-specific rates of surgical site infection (SSI) stratified by National Nosocomial Infection Surveillance System (NNIS) risk index

Footnote: Invasive SSI includes deep incisional and organ/space infections.

G = gamma statistic; CI = confidence interval;

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Figure 2a. Correlation between NNIS risk index and rate of invasive SSI following 7, 032 abdominal hysterectomies

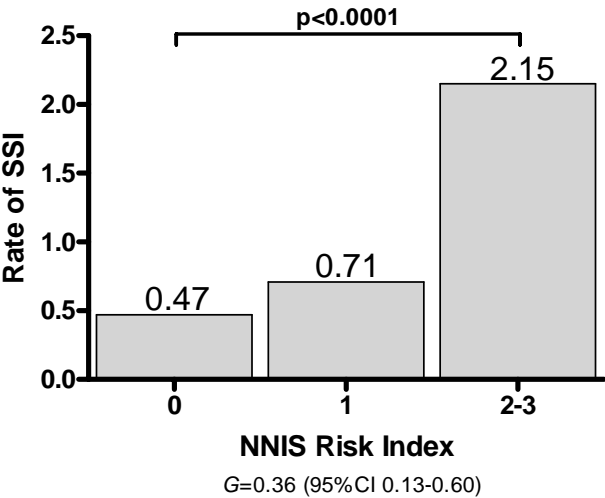
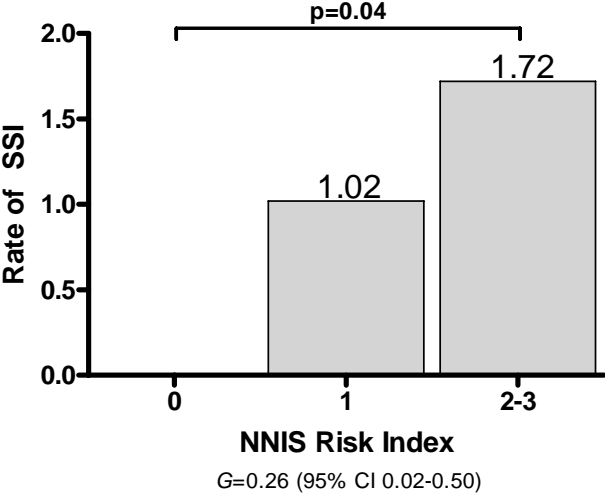


Figure 2b. Correlation between NNIS risk index and rate of invasive SSI following 5,318 cardiothoracic procedures



Footnote: Cardiothoracic procedures included coronary artery bypass grafts (NNIS codes: CBGB and CBGC) and cardiac procedures (NNIS code: CARD)

Figure 2c. Correlation between NNIS risk index and rate of invasive SSI following 5,144 colon procedures

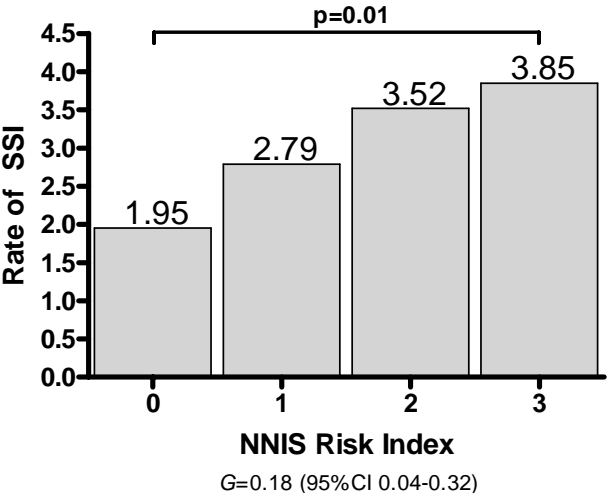


Figure 2d. Correlation between NNIS risk index and rate of invasive SSI following 6,639 hip prosthesis insertions

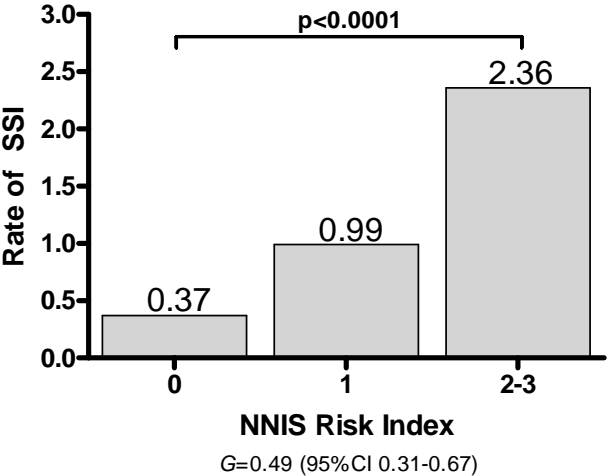


Figure 2e. Correlation between NNIS risk index and rate of invasive SSI following 9,658 knee prosthesis insertions

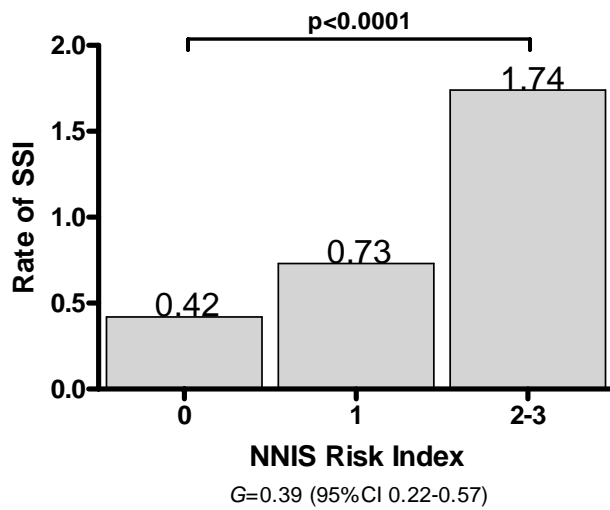
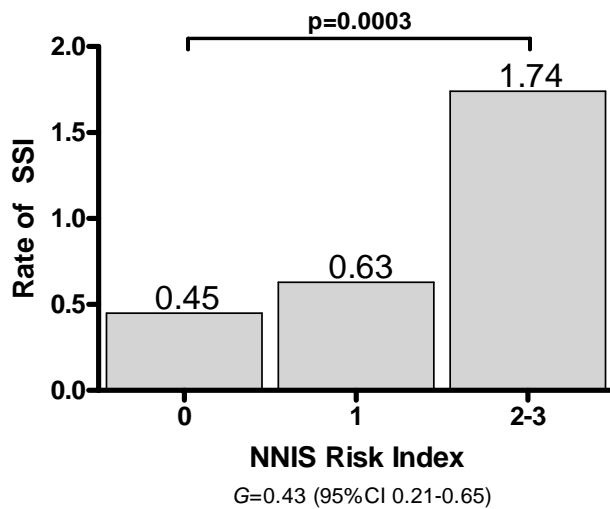


Figure 2f. Correlation between NNIS risk index and rate of invasive SSI following 6,575 vascular procedures



Footnote: Vascular procedures included the general vascular procedures (NNIS code: VASC), abdominal aortic aneurysm repair (AAA), carotid endarterectomy (CEA), and peripheral vein bypass (PVBY).

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