MAJOR ARTICLE

Improving Public Reporting and Data Validation for Complex Surgical Site Infections After Coronary Artery Bypass Graft Surgery and Hip Arthroplasty

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Background. Deep and organ/space surgical site infections (D/OS SSI) cause significant morbidity, mortality, and costs. Rates are publicly reported and increasingly used as quality metrics affecting hospital payment. Lack of standardized surveillance methods threaten the accuracy of reported data and decrease confidence in comparisons based upon these data.

Methods. We analyzed data from national validation studies that used Medicare claims to trigger chart review for SSI confirmation after coronary artery bypass graft surgery (CABG) and hip arthroplasty. We evaluated code performance (sensitivity and positive predictive value) to select diagnosis codes that best identified D/OS SSI. Codes were analyzed individually and in combination.

Results. Analysis included 143 patients with D/OS SSI after CABG and 175 patients with D/OS SSI after hip arthroplasty. For CABG, 9 International Classification of Diseases, 9th Revision (ICD-9) diagnosis codes identified 92% of D/OS SSI, with 1 D/OS SSI identified for every 4 cases with a diagnosis code. For hip arthroplasty, 6 ICD-9 diagnosis codes identified 99% of D/OS SSI, with 1 D/OS SSI identified for every 2 cases with a diagnosis code.

Conclusions. This standardized and efficient approach for identifying D/OS SSI can be used by hospitals to improve case detection and public reporting. This method can also be used to identify potential D/OS SSI cases for review during hospital audits for data validation.

Keywords. coronary artery bypass graft surgery; hip arthroplasty; infection prevention and control programs; surgical site infection; surveillance and public reporting.

Surgical site infections (SSIs) cause significant morbidity and mortality, and they account for over $3 billion in annual costs in the United States [1]. Data suggest that half of these SSIs could be prevented through evidence-based strategies focused on clinical practice improvements [2, 3]. Thus, there has been a national focus on SSI prevention, particularly targeting large volume procedures such as coronary artery bypass graft surgery (CABG) and hip arthroplasty [4]. Each year, 400 000 patients undergo CABG and 450 000 patients undergo hip arthroplasty in US hospitals [5], with the Centers for Disease Control and Prevention's (CDC) National Healthcare Safety Network (NHSN) reporting deep and organ/space SSI rates of 1.5% for CABG and 0.7% for hip arthroplasty [6].

These complex SSIs involve structures deep to the muscle fascia and are associated with a higher risk of death, a higher risk of readmission, longer hospital stays, and higher costs [7–13]. Therefore, reducing deep and organ/space SSIs should significantly reduce morbidity

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and mortality while lowering hospital expenditures. These goals are well aligned with state and national quality improvement initiatives.

At least 21 US states have passed legislation requiring SSI surveillance and reporting, with the majority of these states focusing on SSIs after CABG and hip arthroplasty [14]. In 2012, more than 700 US hospitals performing CABG and more than 1600 US hospitals performing hip arthroplasty reported SSI data from these procedures into NHSN [15]. All US hospitals performing colon surgery and abdominal hysterectomy procedures now publicly report similar data on the Centers for Medicare & Medicaid Services' (CMS) Hospital Compare website [16]. These hospitals will soon be subject to a payment penalty if their reported rates are higher than expected based on national data [17, 18].

Because publicly reported data are increasingly scrutinized and used as quality metrics to determine hospital payment, it is important to validate the data that are reported into NHSN. Despite specific CDC surveillance criteria, implementation varies substantially across hospitals. This variability in active surveillance may lead to bias, with higher SSI rates reported by hospitals with more full-time professionals dedicated to surveillance activities [19]. To address this issue, the CMS Inpatient Quality Reporting Program is evaluating validation strategies to ensure uniform and complete case finding. One such strategy is the screening of administrative claims for diagnosis and procedure codes suggestive of SSI as a trigger for chart review [20]. Prior work has shown that this standardized and efficient method can improve case finding [21–23].

We previously conducted a national validation of claims codes indicative of all SSIs after CABG and hip arthroplasty [21, 23]. Using these data, we now present work that refines claims-based methods to screen specifically for deep and organ/space SSIs after these 2 procedures. The targeting of deep and organ/space SSIs is in line with national surveillance priorities for other surgical procedures.

METHODS

Study Population

Our 2 patient cohorts included the following: (1) Medicare patients ≥65 years old who had undergone CABG (International Classification of Diseases, 9th Revision [ICD-9] codes 36.10–36.17, 36.19, or 36.2) in US hospitals in 2005; and (2) Medicare patients ≥65 years old who had undergone primary hip arthroplasty (ICD-9 codes 81.51 or 81.52) in US hospitals from 2005 through 2007 [21, 23]. In both cohorts, we previously reviewed medical records on a random sample of patients with diagnosis or procedure codes suggestive of SSI in their Medicare Part A and B claims and applied NHSN criteria to confirm SSI [24]. In the current analysis, we focused on the subset of patients in each cohort with a chart-confirmed deep or organ/space SSI. For the subset of patients who underwent saphenous vein harvesting as part of their CABG, we targeted deep and organ/space SSIs at the sternal incision, excluding SSIs at the donor incision.

Refining the Codes

In the prior analyses, we identified 50 ICD-9 codes (12 procedure codes, 38 diagnosis codes) and 18 current procedural terminology [CPT] codes that suggested possible SSI after CABG [21]. We also identified 43 ICD-9 codes (5 procedure codes, 38 diagnosis codes) and 18 CPT codes that suggested possible SSI after hip arthroplasty [23]. In the current analysis, we focused on ICD-9 diagnosis codes only, because we previously found that ICD-9 procedure codes and CPT codes were redundant with the ICD-9 diagnosis codes in identifying SSI [23]. In addition, ICD-9 procedure codes have an impractically complex mapping to the ICD-10 procedure codes, which are scheduled to replace the ICD-9 codes in US hospitals by October 2015 [25].

In refining the codes to target identification of deep and organ/space SSIs, we sought to maximize the sensitivity, the positive predictive value [PPV], and the clinical plausibility of the final code set. The sensitivity is the probability that a patient with a chart-confirmed deep or organ/space SSI had at least 1 of the selected codes in their submitted claims. Prior work found that record review triggered by claims found 92%–100% of the SSIs identified by traditional surveillance. In addition, claims found 2 (CABG) to 5 times (hip arthroplasty) more SSIs than traditional surveillance. For all SSIs identified by either method, claims identified 96%–100% of these infections after CABG and hip arthroplasty [21, 22]. The PPV is the probability that a patient with 1 or more of these codes had a confirmed deep or organ/space SSI on review of the medical record. In other words, the PPV is a measure of how many charts needed to be reviewed for each confirmed deep or organ/space SSI (PPV 50% implies 1 confirmed deep or organ/space SSI for every 2 records reviewed, PPV 33% implies 1 confirmed deep or organ/space SSI for every 3 records reviewed, etc).

We used the branch-and-bound algorithm of Furnival and Wilson [26] to generate candidate code sets. We generated up to 100 models with the best performance characteristics for each number of predictors, ranging from a single code to all 38 diagnosis codes. We then selected the code sets with highest sensitivity for a given PPV (≥50%, 33%, 25%, and 20%). For both procedures, our goal was to achieve a sensitivity ≥90% and a PPV ≥20%. In the case where multiple code sets achieved a similar sensitivity and/or PPV, we used clinical judgment to assess the selected codes, favoring more inclusive sets to account for differential coding across facilities.

In selecting the optimal code set for each procedure, we also sought to identify SSI codes with a straightforward mapping to ICD-10 diagnosis codes [27]. Thus, in the final code sets, we excluded ICD-9 codes with no ICD-10 equivalent, ICD-9 codes that mapped to more than 2 ICD-10 codes, and ICD-9 codes

that mapped to the same ICD-10 code as other ICD-9 codes not indicative of SSI. In excluding these codes, we hope to reduce any possible loss of performance incurred by the change to ICD-10.

Given a national focus on inpatient claims data, we also evaluated the sensitivity of the final code sets when limiting our surveillance to ICD-9 codes submitted in Part A inpatient claims only.

RESULTS

Deep and Organ/Space Surgical Site Infections Identified in National Validation Data Sets

We identified 143 patients with a deep or organ/space SSI after CABG in 78 hospitals from 32 states, and 175 patients with a deep or organ/space SSI after hip arthroplasty in 146 hospitals from 41 states [21, 23]. The CABG patients who developed a deep or organ/space SSI were 41% female with a median age of 73, and the hip arthroplasty patients who developed a deep or organ/space SSI were 66% female with a median age of 80.

For CABG, 94 of the 143 patients (66%) who developed a deep or organ/space SSI were identified after being discharged from the hospital after surgery, with all of these patients requiring rehospitalization. For hip arthroplasty, 174 of the 175 patients (99%) who developed a deep or organ/space SSI were identified postdischarge, with 169 of these 174 patients (97%) requiring rehospitalization.

Identification of Deep and Organ/Space Surgical Site Infection Codes After Coronary Artery Bypass Graft Surgery

Of the 38 ICD-9 diagnosis codes suggestive of any SSI after CABG in our prior published work [21], 27 were found at least once in Medicare claims for the 143 patients with a confirmed deep or organ/space SSI. The individual performance of each of these codes (sensitivity and PPV) is shown in Appendix 1.

Table 1 shows the optimal code set for identifying cases of deep and organ/space SSI after CABG. Limiting medical record review to patients with 1 or more of these 9 codes in their submitted claims identified 92% of the deep and organ/space SSIs identified in our prior national validation project (95% confidence interval [CI], 87%–96%), with 1 deep or organ/space SSI identified on average for every 4 records reviewed (PPV, 26%; 95% CI, 22%–30%). It was possible to improve capture close to 97%, but this required adding nonspecific codes that decreased the PPV to 21%. These codes are also shown in Table 1.

Each of the ICD-9 diagnosis codes in the recommended code set has a simple cross-walk to ICD-10 diagnosis codes (see Table 2). Four ICD-9 diagnosis codes that had been selected by the algorithm were excluded from the optimal code set. The ICD-9 code 730.28 does not have an ICD-10 equivalent. The ICD-9 codes 519.2, 686.8, and 875.0 each map to the same ICD-10 code as other ICD-9 codes not indicative of SSI. The exclusion of these 4 ICD-9 diagnosis codes from the optimal code set only decreased the sensitivity from 93% to 92%.

When we limited our analysis to Part A inpatient claims only, and the 9 codes in the optimal code set identified 87% of the deep and organ/space SSIs after CABG.

Identification of Deep and Organ/Space Surgical Site Infection Codes After Hip Arthroplasty

Of the 38 ICD-9 diagnosis codes suggestive of SSI after hip arthroplasty in our prior published work [23], 28 were found at least once in Medicare claims for the 175 patients with a confirmed deep or organ/space SSI. The individual performance of each of these codes (sensitivity and PPV) is shown in Appendix 2.

Table 1 shows the optimal code set for identifying cases of deep and organ/space SSI after hip arthroplasty. Limiting medical record review to patients with 1 or more of these 6 codes in their submitted claims identified 99% of the deep and organ/space SSIs identified in our prior national validation project (95% CI, 98%–100%), with 1 deep or organ/space SSI identified on average for every 2 records reviewed (PPV, 47%; 95% CI, 41%–52%).

Each of the ICD-9 diagnosis codes in the optimal code set has a simple cross-walk to ICD-10 diagnosis codes (see Table 2). No ICD-9 diagnosis codes that had been selected by the algorithm were excluded from the optimal code set due to ICD-10 incompatibility.

When we limited our analysis to Part A inpatient claims only, the 6 codes in the optimal code set identified 92% of the deep and organ/space SSIs after hip arthroplasty.

DISCUSSION

Reported SSI rates are increasingly used as hospital quality metrics with significant financial implications for individual hospitals. Although surveillance definitions are standardized, their application remains variable and resource intensive, especially because the majority of SSIs occur after a patient has been discharged from the hospital after surgery [28, 29]. Our results indicate that a claims-based surveillance approach successfully identifies deep and organ/space SSIs after CABG and hip arthroplasty. This methodology can be used by hospitals for comprehensive and efficient SSI detection, and it can be used by CMS and state health departments for validation of publicly reported data.

Overall, 9 out of 10 deep and organ/space SSIs are diagnosed in the inpatient setting [30]. In lieu of manually reviewing the experience of all postoperative patients, we suggest that hospital infection prevention programs could instead review patients with diagnosis codes suggestive of SSI. Implementing claims-based methods to investigate cases most likely to have an infection can improve case identification, both during the surgical admission and on readmission to the hospital where the surgery was performed. Adoption of this methodology can improve public reporting of SSI data, while improving efficiency for infection control departments.

Table 1. ICD-9 Code Sets That Best Identify Deep and Organ/Space Surgical Site Infections After Coronary Artery Bypass Graft Surgery and Hip Arthroplasty

ICD-9	Description	Sensitivity*	PPV*
Coronary Artery Bypass Graft Surgery			
Optimal Code Set		92% *(87%–96%)*	26% *(22%–30%)*
513.1	Abscess of mediastinum	*Using these codes, expect to find 92% of the deep and organ/space SSIs, 1 for every 4 records reviewed*	
682.2	Cellulitis of trunk		
730.08	Acute osteomyelitis, other specified sites		
996.61	Infection and inflammatory reaction due to cardiac device, implant		
996.62	Infection and inflammatory reaction due to vascular device, implant		
998.31	Disruption of internal operation wound		
998.32	Disruption of external operation wound		
998.51	Infected postoperative seroma		
998.59	Other postoperative infection		
Alternative Code Set[†]		97% *(93%–100%)*	21% *(18%–24%)*
ICD-9 codes 513.1, 682.2, 730.08, 996.61, 996.62, 998.31, 998.32, 998.51, and 998.59 *PLUS*:		*Using these codes, expect to find 97% of the Deep and Organ/Space SSIs, 1 for every 5 records reviewed*	
785.52	Septic shock		
790.7	Bacteremia		
998.83	Nonhealing surgical wound		
Hip Arthroplasty			
Optimal Code Set		99% *(98%–100%)*	47% *(41%–52%)*
996.60	Infection and inflammatory reaction due to unspecified device, implant	*Using these codes, expect to find 99% of the deep and organ/space SSIs, 1 for every 2 records reviewed*	
996.66	Infection and inflammatory reaction to internal joint prosthesis		
996.67	Infection and inflammatory reaction to internal orthopedic device, implant		
996.69	Infection and inflammatory reaction due to internal prosthetic implant		
998.51	Infected postoperative seroma		
998.59	Other postoperative infection		
Alternative Code Set[‡]		99% *(98%–100%)*	49% *(44%–54%)*
996.66	Infection and inflammatory reaction to internal joint prosthesis	*Using these codes, expect to find 99% of the deep and organ/space SSIs, 1 for every 2 records reviewed*	
996.67	Infection and inflammatory reaction to internal orthopedic device, implant		
998.59	Other postoperative infection		

Abbreviations: ICD-9, International Classification of Diseases, 9th Revision; PPV, positive predictive value; SSI, surgical site infection.

* Data presented with 95% confidence intervals.

[†] This code set is considered less optimal despite a higher sensitivity, due to the fact that these diagnoses are less specific to surgical site infection.

[‡] This code set is considered less optimal despite similar performance, due to the higher risk that alternate codes are used by some hospitals to indicate SSI and also the higher risk for gaming, whereby hospitals can find and use alternative codes to avoid SSI detection.

In prior work, we showed that traditional surveillance practices identified only 48% of chart-confirmed SSIs after CABG and 21% of chart-confirmed SSIs after hip arthroplasty [21, 22]. In the current report, we found that 92% of deep and organ/space SSIs after CABG and 99% of deep and organ/space SSIs after hip arthroplasty can be identified using diagnosis codes. Although the diagnosis codes for a hospital admission might not be available until after a patient has been discharged, most infection prevention programs currently perform SSI surveillance after the requisite 90-day window has passed for SSI determination based upon CDC criteria. Faster access to claims and real-time review of SSI may be possible in the future-based, increasingly electronic health records.

Although claims enable the ability to track SSIs that present to hospitals other than the hospital performing the surgery, current practices do not fully ensure that these SSIs are communicated back to the hospital performing the surgery. In the future, it may be possible for states to use mandated hospitalization datasets to feedback claims suggestive of SSI from any facility to the hospital performing the surgery, but this requires an infrastructure that does not currently exist.

At this time, Medicare's Hospital Compare website reports on complications for patients who have undergone hip and knee arthroplasty [16]. Among other things, this performance metric includes an assessment of periprosthetic joint infection based upon 12 ICD-9 diagnosis codes and 21 ICD-9 procedure codes, with the requirement that 1 of each type is present [31,

Table 2. ICD-9 to ICD-10 Cross-Walk for Codes Suggestive of a Deep or Organ/Space Surgical Site Infection After Coronary Artery Bypass Graft Surgery and Hip Arthroplasty

ICD-9 Code	ICD-10 Cross-Walk	ICD-10 Code Description
Coronary Artery Bypass Graft Surgery		
513.1	J853	Abscess of mediastinum
682.2	L03319	Cellulitis of trunk, unspecified
730.08	M8618	Other acute osteomyelitis, other site
	M8628	Subacute osteomyelitis, other site
996.61	T826XXA	Infection and inflammatory reaction due to cardiac valve prosthesis, initial encounter
996.61 996.62	T827XXA	Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts, initial encounter
998.31	T8132XA	Disruption of internal operation (surgical) wound, not elsewhere classified, initial encounter
998.32	T8131XA	Disruption of external operation (surgical) wound, not elsewhere classified, initial encounter
998.51 998.59	T814XXA	Infection following a procedure, initial encounter
Hip Arthroplasty		
996.60 966.69	T8579XA	Infection and inflammatory reaction due to other internal prosthetic devices, implants and grafts, initial encounter
996.66	T8450XA	Infection and inflammatory reaction due to unspecified internal joint prosthesis, initial encounter
996.67	T847XXA	Infection and inflammatory reaction due to other internal orthopedic prosthetic devices, implants and grafts, initial encounter
	T8460XA	Infection and inflammatory reaction due to internal fixation device of unspecified site, initial encounter
998.51 998.59	T814XXA	Infection following a procedure, initial encounter

Abbreviations: ICD-9, International Classification of Diseases, 9th Revision.

32]. This methodology identified only 57% of the confirmed deep or organ/space SSIs in our hip arthroplasty cohort. This result compares with the 99% sensitivity presented in our results, using 6 ICD-9 diagnosis codes not paired with any ICD-9 procedure codes. A more formal comparison of these 2 methods of identifying SSI using claims may be warranted. With that said, the inclusion of ICD-9 procedure codes in the Hospital Compare measure will pose difficulties when transitioning to ICD-10 due to the complex mapping, with each ICD-9 procedure code mapping to multiple ICD-10 procedure codes. This process is less of a problem when mapping from ICD-9 to ICD-10 diagnosis codes.

In selecting an optimal code set to support surveillance, it is important to select sets that are sufficiently broad to account for variations in coding practice across healthcare facilities and to limit the potential for gaming by avoiding specific codes. As one example of the need to avoid gaming, the ICD-9 code for mediastinitis (519.2) was infrequently used once it was identified as a marker of a hospital-acquired condition for which Medicare reimbursement would be limited [33]. Even prior to this decline in use, this single code for mediastinitis only identified 13% of the deep and organ/space SSIs after CABG noted in this cohort (see Appendix 1). We specifically selected code sets that accounted for variations in coding practice across healthcare facilities by incorporating a sufficient breadth of codes to mitigate intentional changes in coding practices to avoid penalty.

Our study does have limitations. First, we did not include revision arthroplasty procedures or SSIs occurring at secondary surgical sites after CABG (ie, a donor incision used for saphenous vein harvesting). It is possible that alternative codes might be required to improve case capture after these other types of procedures. Second, it is possible that the presented code sets may have different performance characteristics in different hospitals. The strength of this work is the inclusion of codes from a large number of US hospitals. Therefore, differences in coding practices ought to be accounted for in our analysis. Third, the sensitivity that we report for the optimal code sets is the probability that a patient with a chart-confirmed deep or organ/space SSI had at least 1 of these codes. We selected records nationally for chart review based on the presence of billing codes suggestive of SSI. Although it is possible that some patients who developed an SSI might not be identified by this approach, our prior work has shown claims-based surveillance to have a very high sensitivity compared with traditional surveillance [21, 22].

CONCLUSIONS

In summary, we have shown that claims-based methods provide a comprehensive, automated, and efficient way to trigger chart

review for identification of deep and organ/space SSIs after CABG and hip arthroplasty. Surgical site infection data are increasingly used as quality metrics, impacting both facility and provider selection by patients and hospital payment based on implied performance. Our methodology directly addresses the variation in current SSI surveillance methods across hospitals and offers a standardized approach to improve SSI surveillance efforts and to validate publically reported data.

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Appendix 1. Individual Code Performance for Identifying Patients With a Deep or Organ/Space Surgical Site Infection After Coronary Artery Bypass Graft Surgery

ICD-9	Description	D/OS SSI*	No D/OS SSI†	Sensitivity‡	PPV
Diagnosis					
513.1	Abscess of mediastinum	3	1	2%	75%
519.2	Mediastinitis	19	3	13%	86%
682.2	Cellulitis of trunk	20	54	14%	27%
682.3	Cellulitis of upper arm/forearm	2	46	1%	4%
682.8	Cellulitis, other specified sites	2	13	1%	13%
686.8	Other specified local infection, skin/soft tissue	1	6	1%	14%
686.9	Unspecified local infection, skin/soft tissue	9	37	6%	20%
730.08	Acute osteomyelitis, other specified sites	12	2	8%	86%
730.20	Unspecified osteomyelitis, site unspecified	5	6	4%	45%
730.28	Unspecified osteomyelitis, other specified sites	18	5	13%	78%
730.89	Other infections involving bone, multiple sites	1	0	1%	100%
785.52	Septic shock	8	56	6%	13%
790.7	Bacteremia	24	121	17%	17%
875.0	Open wound into thoracic cavity, without complication	24	32	17%	43%
879.8	Open wounds without mention of complication	1	11	1%	8%
879.9	Open wounds, unspecified, complicated	1	7	1%	13%
891.0	Open wound of leg without mention of complication	2	25	1%	7%
891.1	Open wound of leg with complication	2	22	1%	8%
996.61	Infection/inflammation, cardiac device, implant	8	30	6%	21%
996.62	Infection/inflammation, vascular device, implant	8	63	6%	11%
996.71	Other complications due to heart valve prosthesis	1	21	1%	5%
998.31	Disruption of internal operation wound	39	31	27%	56%
998.32	Disruption of external operation wound	57	95	40%	38%
998.51	Infected postoperative seroma	8	14	6%	36%
998.59	Other postoperative infection	99	192	69%	34%
998.83	Nonhealing surgical wound	24	76	17%	24%
998.9	Unspecified complication of procedure	8	15	6%	35%

Abbreviations: D/OS SSI, deep or organ/space surgical site infection; ICD-9, International Classification of Diseases, 9th Revision; PPV, positive predictive value.

* Number of patients with D/OS SSI identified by code.

† Number of patients with no D/OS SSI identified by code.

‡ Out of 143 D/OS SSIs in study population.

Appendix 2. Individual Code Performance for Identifying Patients With a Deep or Organ/Space Surgical Site Infection After Hip Arthroplasty

ICD-9	Description	D/OS SSI*	No D/OS SSI†	Sensitivity‡	PPV
Diagnosis					
686.8	Other specified local infection, skin/soft tissue	3	5	2%	38%
686.9	Unspecified local infection, skin/soft tissue	27	91	15%	23%
711.00	Pyogenic arthritis, site unspecified	12	7	7%	63%
711.05	Pyogenic arthritis, pelvis and thigh	44	5	25%	90%
711.08	Pyogenic arthritis, other specified sites	5	0	3%	100%
711.09	Pyogenic arthritis, multiple sites	2	2	1%	50%
711.90	Unspecified infective arthritis, site unspecified	1	3	1%	25%
711.95	Unspecified infective arthritis, pelvis and thigh	32	4	18%	89%
711.98	Unspecified infective arthritis, other specified sites	2	1	1%	67%
730.00	Acute osteomyelitis, site unspecified	2	7	1%	22%
730.05	Acute osteomyelitis, pelvis and thigh	8	2	5%	80%
730.08	Acute osteomyelitis, other specified sites	2	3	1%	40%
730.10	Chronic osteomyelitis, site unspecified	2	4	1%	33%
730.15	Chronic osteomyelitis, pelvis and thigh	4	5	2%	44%
730.20	Unspecified osteomyelitis, site unspecified	18	28	10%	39%
730.25	Unspecified osteomyelitis, pelvis and thigh	14	6	8%	70%
730.28	Unspecified osteomyelitis, other specified sites	4	12	2%	25%
730.29	Unspecified osteomyelitis, multiple sites	1	0	1%	100%
730.90	Unspecified infection of bone, site unspecified	2	1	1%	67%
730.95	Unspecified infection of bone, pelvis and thigh	7	0	4%	100%
730.98	Unspecified infection of bone, other specified sites	2	1	1%	67%
996.60	Infection/inflammation, unspecified device, implant	14	4	8%	78%
996.66	Infection/inflammation, internal joint prosthesis	143	35	82%	80%
996.67	Infection/inflammation, internal orthopedic device, implant	47	15	27%	76%
996.69	Infection/inflammation, internal prosthetic implant	11	8	6%	58%
998.51	Infected postoperative seroma	12	15	7%	44%
998.59	Other postoperative infection	138	157	79%	47%
998.6	Persistent postoperative fistula	3	2	2%	60%

Abbreviations: D/OS SSI, deep or organ/space surgical site infection; ICD-9, International Classification of Diseases, 9th Revision; PPV, positive predictive value.

* Number of patients with deep incisional or organ/space SSI identified by code.

† Number of patients with no deep incisional or organ/space SSI identified by code.

‡ Out of 175 deep incisional and organ/space SSIs in study population.