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Is The American Joint Replacement Registry Able to Correctly Classify Revision Total Knee Arthroplasty Procedural Diagnoses?

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Abstract

Introduction: The American Joint Replacement Registry (AJRR) is a powerful tool for the study of revision total knee arthroplasty (rTKA). The AJRR utilizes International Classification of Diseases-10 (*ICD-10-CM*) codes for recording surgical diagnoses. However, the validity of this methodology is unknown. The purpose of this study was to determine the accuracy of *ICD-10-CM* codes, as used by AJRR, in classifying rTKA diagnoses.

Methods: There were 988 rTKAs performed from 2015 to 2021 identified in our institutional total joint registry (TJR). Revision diagnoses were obtained from TJR, in which trained abstractors prospectively record diagnoses independent of *ICD-10-CM* data. The *ICD-10-CM* diagnosis codes submitted to AJRR were retrieved for the same procedures. The accuracy of *ICD-10-CM* codes for classifying rTKA diagnoses as septic vs aseptic, aseptic loosening, instability, and periprosthetic fracture was assessed using Cohen's Kappa statistics, sensitivities, and specificities.

Results: Concordance between AJRR submitted codes and TJR was excellent (97.3%, k=0.9) for identifying septic versus aseptic revisions. Agreement for aseptic diagnoses varied from very good for loosening (k=0.65) and instability (k=0.64) to fair for periprosthetic fracture (k=0.36). Specificity was high (>94%) for all three diagnoses, but sensitivity was lower at 71, 63, and 28% for loosening, instability, and periprosthetic fracture, respectively.

Conclusion: The AJRR submitted *ICD-10-CM* diagnosis codes correctly classified rTKA cases as septic or aseptic with remarkable accuracy, but accuracy for more granular diagnoses

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varied. These data demonstrate the potential for diagnosis-specific limitations when utilizing administrative claims data for registry reporting and have important implications for researchers using *ICD-10-CM* data.

Keywords

revision; total knee arthroplasty; registry; AJRR; ICD-10

Introduction

Administrative claims data has become increasingly utilized in total knee arthroplasty (TKA) research.[1–4] With this, concern has surfaced over the accuracy of utilizing administrative claims data for research and quality assessment of TKA procedures.[4–7] Prior authors have examined the validity of using the Ninth iteration of the International Classification of Diseases (*ICD-9-CM*) diagnosis codes for total joint arthroplasty research,[5] but the Tenth iteration (*ICD-10-CM*), which constituted a marked increase in diagnostic granularity and complexity, has not been fully assessed.[6, 7] While one of the major purposes of the transition to *ICD-10-CM* coding was to provide more accurate and comprehensive capture of clinical data,[8] some authors have questioned whether the increased complexity of *ICD-10-CM* coding may inadvertently diminish coding accuracy.[6, 7, 9–11]

Understanding the accuracy of *ICD-10-CM* diagnostic codes is even more pertinent with the establishment and rapid growth of the American Joint Replacement Registry (AJRR).[12] The AJRR was created in 2009 and since that time has successfully grown to become the largest arthroplasty registry in the world by annual procedural count.[13] Currently, the AJRR utilizes *ICD-10-CM* diagnostic codes to record surgical diagnoses. However, it is not yet known whether *ICD-10-CM* diagnosis codes can be accurately utilized to determine surgical diagnoses. To date, external validation of AJRR data has been aimed at either comparing data to other national registries[14] or has evaluated ICD procedural coding system (*PCS)* codes only.[6, 7]

While these prior investigations are informative, *ICD-10-PCS* codes only identify which procedures have taken place and do not provide any information on the diagnosis prompting revision. As diagnosis codes are critical to the accurate interpretation and reporting of data within the AJRR, it is necessary to determine the accuracy with which *ICD-10-CM* codes capture the correct surgical diagnosis. Therefore, the aim of this study was to compare revision TKA (rTKA) diagnosis concordance between a prospectively curated institutional total joint registry and administrative claims (*ICD-10-CM*) data submitted to AJRR, so that the accuracy of *ICD-10-CM* diagnosis data for rTKA could be assessed.

Methods

After Institutional Review Board approval, rTKA cases performed between October 1, 2015 and December 31, 2021 were identified within our institutional total joint registry (TJR). October 1, 2015 was chosen as the start date for this study as this represents the date of transition from *ICD-9-CM* to *ICD-10-CM* coding within the United States.[6] The data

contained within our institutional TJR are prospectively recorded by trained data abstractors independent of administrative claims documentation. In the case of surgical diagnoses for each rTKA procedure, these are manually abstracted from clinical and operative notes of the procedure, providing accurate diagnostic data. The revision diagnosis documented within our institutional TJR was considered the true revision diagnosis for this study.

After identification of this rTKA cohort, *ICD-10-CM* diagnosis data, as submitted to AJRR by our institution was retrieved for the same rTKA procedures. At our institution, these diagnoses codes are selected and entered by advanced practice providers or house staff under the direction of consultant surgeons. A unique identifier was then created which combined the patient medical record number and date of surgery such that it was ensured that the correct patient and correct surgery were being compared between databases. This resulted in a cohort of 988 unique rTKA procedures for analyses.

The AJRR accepts up to ten *ICD-10-CM* diagnosis codes per submitted case with one code being designated as the principal diagnosis. Additionally, there are numerous *ICD-10-CM* diagnosis codes related to failure modes of knee prostheses. A portion of these codes are specific to prosthetic implants, such as code M97.11 (Periprosthetic fracture around internal prosthetic right knee joint). However, there are many other *ICD-10-CM* diagnostic codes that could be utilized to reflect a diagnosis for knee prosthesis failure – when linked with a knee revision procedure – without being a prosthesis-specific code, such as S72.421 (Displaced fracture of the lateral condyle of the right femur). If either of these two example codes were listed as a diagnosis for a rTKA, it would be reasonable to assume the prosthesis was revised due to periprosthetic fracture. Given the multiple diagnostic codes that can be submitted to AJRR and the various types of diagnostic codes available, *ICD-10-CM* data can be queried by researchers in a variety of ways.

To provide a complete assessment of the accuracy of *ICD-10-CM* diagnosis codes for rTKA, we evaluated *ICD-10-CM* diagnoses codes submitted to AJRR by varying the analysis based upon the diagnostic position of a code (principal diagnosis vs all submitted *ICD-10-CM* diagnoses) and the type of diagnosis code submitted (prosthetic joint-specific diagnosis codes [ie. T84.54, Infection and inflammatory reaction due to internal right knee prosthesis] versus any ICD-code related to the examined diagnosis category [ie. A40.0 Sepsis due to streptococcus, group A]). Therefore, the accuracy of *ICD-10-CM* diagnosis codes submitted to AJRR were compared with four distinct query methods which evaluated: 1) only prosthetic joint-specific diagnosis codes present in the principal diagnosis position (PS-PD); 2) any-diagnosis-related code present in the principal diagnosis position (AR-PD); 3) only prosthetic joint-specific diagnosis codes present in any of the 10 diagnostic positions (PS-AD), and; 4) any-diagnosis-related code present in any of the 10 diagnostic positions (AR-AD). The *ICD-10-CM* diagnosis codes utilized, as well as those considered “prosthetic joint specific”, for the identification of each diagnosis can be seen in Appendix 1.

These four analyses were each independently conducted in a stepwise fashion. We first assessed the accuracy of *ICD-10-CM* diagnosis codes for classifying septic versus aseptic rTKA procedures. Subsequently, we analyzed known aseptic rTKA procedures to determine the accuracy of *ICD-10-CM* diagnosis codes for identifying the three most common aseptic

revision diagnoses: aseptic loosening, instability, and periprosthetic fracture.[15] Therefore, a diagnoses of infection took precedence over other incidentally present diagnoses. For instance, a knee which was infected and loose would simply be considered an infection for the purposes of this study. For that reason, infection cases were not included in the analysis of aseptic diagnoses codes.

Statistical analyses were then performed to assess concordance between the two registries. Concordance was assessed in five ways. First, Cohen's kappa statistic was calculated and was assessed using grading criteria per precedence in the literature: κ = 0.20 to 0.39, fair; κ = 0.40 to 0.59, moderate; κ = 0.60 to 0.79, very good; κ greater than 0.80, excellent.[5] Next the following four parameters were calculated: sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). As the calculation of PPV and NPV require a known prevalence, the prevalence of each diagnosis was derived from our institutional registry by dividing number of cases with the diagnosis by the total number of included rTKA cases.

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Results:

True Revision TKA Diagnoses

A total of 988 rTKA procedures were included in this study. Of these, 171 (17.3%) were septic rTKA performed for infectious indications. Of the 817 remaining aseptic rTKA procedures, 413 were performed for aseptic loosening (50.1%), 294 for instability (36%), and 25 for periprosthetic fracture (3.1%).

Septic versus Aseptic Diagnoses

The concordance between registries with regards to an infectious indication for rTKA was excellent and concordance was optimized by querying for any infection-related-code in either the principal-diagnosis-only (AR-PD) (97.5% agreement, k=0.91, 95% confidence interval (CI) 0.87–0.94)) or any-submitted-diagnosis position (AR-AD) (97.3% agreement, k=0.90, 95% CI 0.87–0.94). The concordance dropped to moderate when querying prosthetic infection-specific-codes only in either the principal-diagnosis-position-only (PS-PD) (89.3% agreement, k=0.51, 95%CI 0.43–0.58) or in any-submitted-diagnosis position (PS-AD) (90.4% agreement, k=0.58, 95%CI 0.5–0.65). This drop in concordance when querying only for prosthetic infection-specific-codes, rather than any-infection-related-code, was due to lower sensitivity when using only prosthetic infection-specific-codes. For instance, querying by AR-AD resulted in a sensitivity of 88.3% while querying PS-AD resulted in a sensitivity of 45.6%. Despite this, PPV (>95%) and specificity (>99%) remained high for all four querying methods to identify septic versus aseptic rTKA procedures (Table 1).

Aseptic Diagnoses

The concordance between registries for the rTKA diagnosis of aseptic loosening was very good (k≥0.64) with little variation in the concordance obtained with different querying methods (Table 1). The percent accuracy for rTKA diagnosis of aseptic loosening ranged from 82.1–82.5% and kappa ranged from 0.64–0.65 depending upon method of query. Sensitivity for detecting loosening ranged from 70 to 71%, but specificity remained high ≥94% for all 4 methods of query.

Concordance between registries for the rTKA diagnosis of instability ranged from moderate (k=0.59) to very good (k=0.64) depending on query method (Table 1). Agreement between registries was optimized when querying by PS-AD and AR-AD (84.8 and 84.7% agreement, respectively). Sensitivity was slightly lower and ranged from 57 to 63% for all methods of query. However, specificity remained high (≥96%) for all four query methods. As such, the PPV was also high at ≥92% for the rTKA diagnosis of instability.

Registry concordance for the rTKA diagnosis of periprosthetic fracture was lower than other diagnoses. Concordance was again optimized by querying via PS-AD and AR-AD (both k=0.36) rather than by PS-PD or AR-PD (k=0.24). While percent agreement between registries remained high (97%), sensitivity was low and ranged from 16 to −28% due to many patients being inaccurately not coded as periprosthetic fracture in the *ICD-10-CM* diagnosis data submitted to AJRR. Specificity remained high at >99% for all 4 query methods for rTKA diagnosis of periprosthetic fracture (Table 1).

Discussion

The availability of administrative claims data in commercially available databases has led to a rapid increase in their utilization for arthroplasty research and quality assessment.[1–3] Additionally, the AJRR utilizes *ICD-10-CM* diagnosis codes to determine surgical diagnosis in rTKA procedures. As the AJRR continues to mature and is utilized for research, quality reporting, implant surveillance and the generation of annual reports utilized by multiple stake holders, understanding the validity of using *ICD-10-CM* codes in this manner is critical. The findings from this study demonstrate that the *ICD-10-CM* data submitted to AJRR was able to classify rTKA cases as septic or aseptic with remarkable accuracy. However, for more granular aseptic diagnoses, the concordance was more variable and ranged from fair for periprosthetic fracture to very good for aseptic loosening and instability. We found that method of query was important and influenced the sensitivity for many diagnoses. Reassuringly, the specificity of *ICD-10-CM* diagnosis codes remained universally high. These data demonstrate the potential for diagnosis specific limitations when utilizing administrative claims data for registry reporting and have important implications for researchers using *ICD-10-CM* data for evaluating rTKA procedures.

To date, there have been limited efforts made at validating the use of *ICD-10-CM* codes submitted to AJRR.[6, 7] In the case of rTKA, prior work has demonstrated that *ICD-10* procedural codes accurately (98%) identify that a rTKA has occurred, but that more granular procedural details, such as which components were removed and replaced, are up to 40% inaccurate.[6] These findings are not completely dissimilar to those demonstrated in this

study. We found that when using *ICD-10-CM* diagnosis codes, accuracy was remarkably high for determining whether or not a rTKA was performed for septic or aseptic indications, but more granular diagnoses had lower concordance and a higher rate of misclassification, particularly in the case of periprosthetic fracture. Taken together, this suggests that *ICD-10* codes can be accurately utilized at less granular levels, but it must be understood that some degradation of accuracy occurs as more granular analyses are performed. This has important and obvious implications for performing and interpreting research using administrative claims data.[16]

Bozic et al. performed a similar evaluation of the validity of using *ICD-9-CM* codes in total joint arthroplasty research.[5] In their study, using only prosthesis-specific-codes, the authors assessed kappa statistic, sensitivity, and PPV for various revisions diagnoses. They reported a kappa of 0.66 (very good concordance) for periprosthetic joint infection. While we found much higher concordance with the use of any infection-related code (k=0.91, excellent concordance), when using only the prosthesis-specific-codes we found similar concordance to these prior authors (k= 0.51–0.58).[5] Similarly, the concordance reported using *ICD-9-CM* codes for aseptic loosening was identical to that found in the current investigation (k=0.64 for both). However, results were markedly different between the current investigation and this prior study with regards to instability and periprosthetic fracture. The concordance in the current study was higher for instability (k=0.64) than previously reported using *ICD-9-CM* codes (k=0.47). This suggests that with regards to instability, *ICD-10-CM* diagnosis codes may have improved upon their prior iteration. Contrarily, however, with regards to periprosthetic fracture, we found much lower concordance (k=0.36) than previously reported (k=0.73) for *ICD-9-CM* codes. This could be due to the low number of included fractures in this series but was generally driven by a lack of sensitivity when using *ICD-10-CM* codes despite very high specificity.[5]

A very important finding of this study is that the method of query can have a large influence on the accuracy with which true operative diagnoses are identified when utilizing *ICD-10-CM* diagnosis data. This has relevance for AJRR as well as for other research using administrative claims data. In general, for aseptic diagnoses, we found that concordance and sensitivity were optimized by querying using all submitted diagnoses rather than just the principal diagnosis. However, the influence of query method was greater for delineating septic versus aseptic rTKA procedures where infection was identified with much higher sensitivity when using any code related to infection rather than only codes which were prosthesis-specific-codes. Importantly, specificity remained high regardless of query method for all 4 examined diagnoses (>94% for all). This is reassuring as it suggests that despite the query methodology, a highly specific cohort can be obtained reliably with *ICD-10-CM* diagnosis codes. That being stated, our methodology should be noted. In the analysis of aseptic diagnoses, we first identified and excluded patients who had a coded infection and only subsequently sought to identify the aseptic diagnosis. Therefore, we would recommend this be the procedure utilized in any future studies evaluating claims data; particularly when evaluating aseptic revision indications in order to minimize misclassification.

Misclassification of surgical diagnoses (either as exposure, outcome or covariate) can impact measures of association and the interpretation of AJRR studies.[16] It is therefore important

to consider the degree of misclassification, whether misclassification is differential or non-differential and the direction toward which the association between the exposure and outcome might be biased due to misclassification. Validation estimates from this study can be used for quantitative bias analysis to examine whether and how misclassification might affect study results.

There are several potential limitations to this study which warrant further discussion. This is a review of data from a single institution. While we included a large number of rTKA procedures, it is possible that systematic processes which are in place improve coding accuracy or lead to inaccuracies which may not be seen at another institution. For this reason, these data will require multi-institutional confirmation. Also, it is likely that not every possible *ICD-10-CM* code related to each diagnosis is included in this study, leading to less accuracy than would otherwise be obtained. However, we utilized codes as identified by AJRR and therefore this analysis should reflect AJRR's interpretation of this data accurately. In addition, referral and consult patterns influence the local prevalence of certain diagnoses. For instance, at our institution, the volume of periprosthetic fracture cases may be lower than at other institutions. How this influenced our results is difficult to definitively ascertain and should be clarified in further studies.

In conclusion, the AJRR can utilize *ICD-10-CM* codes to classify rTKA cases as septic or aseptic with extraordinary accuracy, but this accuracy is sensitive to query methodology. More granular aseptic diagnoses can still be identified with very good accuracy and high specificity in most cases, but some diagnoses (i.e. periprosthetic fracture) had only fair concordance due to very low sensitivity when using the *ICD-10-CM* codes. This study is encouraging, but also should serve as a precaution against the performance of hyper-granular analyses that are reliant on accurate administrative claims billing data.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix

Appendix Table 1.

Categorized AJRR ICD10 Diagnosis Codes

ICD Code	Diagnosis
	Infection
A40.8	Other streptococcal sepsis
A41.01	Sepsis due to Methicillin susceptible Staphylococcus aureus
A41.02	Sepsis due to Methicillin resistant Staphylococcus aureus

ICD Code	Diagnosis
A41.1	Sepsis due to other specified staphylococcus
A41.51	Sepsis due to Escherichia coli [E. coli]
A41.81	Sepsis due to Enterococcus
A49.01	Methicillin susceptible Staphylococcus aureus infection, unspecified site
A49.02	Methicillin resistant Staphylococcus aureus infection, unspecified site
B95.4	Other streptococcus as the cause of diseases classified elsewhere
B95.61	Methicillin susceptible Staphylococcus aureus infection as the cause of diseases classified elsewhere
B95.62	Methicillin resistant Staphylococcus aureus infection as the cause of diseases classified elsewhere
B95.8	Unspecified staphylococcus as the cause of diseases classified elsewhere
B96.20	Unspecified Escherichia coli [E. coli] as the cause of diseases classified elsewhere
L02.415	Cutaneous abscess of right lower limb
L02.416	Cutaneous abscess of left lower limb
M00	Pyogenic arthritis
M00.069	Staphylococcal arthritis, unspecified knee
M00.06	Staphylococcal arthritis, knee
M00.869	Arthritis due to other bacteria, unspecified knee
M00.862	Arthritis due to other bacteria, left knee
M00.9	Pyogenic arthritis, unspecified
M86	Osteomyelitis
M86.062	Acute hematogenous osteomyelitis, left tibia and fibula
M86.152	Other acute osteomyelitis, left femur
M86.161	Other acute osteomyelitis, right tibia and fibula
M86.162	Other acute osteomyelitis, left tibia and fibula
M86.169	Other acute osteomyelitis, unspecified tibia and fibula
M86.361	Chronic multifocal osteomyelitis, right tibia and fibula
M86.461	Chronic osteomyelitis with draining sinus, right tibia and fibula
M86.462	Chronic osteomyelitis with draining sinus, left tibia and fibula
M86.661	Other chronic osteomyelitis, right tibia and fibula
M86.9	Osteomyelitis, unspecified
T81.4	Infection following a procedure
T81.40	Infection following a procedure, unspecified
T81.42	Infection following a procedure, deep incisional surgical site
T81.43	Infection following a procedure, organ and space surgical site
T81.49	Infection following a procedure, other surgical site
T83.511	Infection and inflammatory reaction due to indwelling urethral catheter
T83.518	Infection and inflammatory reaction due to other urinary catheter
T83.598	Infection and inflammatory reaction due to other prosthetic device, implant and graft in urinary system
T84.5	**Infection and inflammatory reaction due to internal joint prosthesis**
T84.50	**Infection and inflammatory reaction due to unspecified internal joint prosthesis**
T84.53	**Infection and inflammatory reaction due to internal right knee prosthesis**
T84.54	**Infection and inflammatory reaction due to internal left knee prosthesis**
T84.59	**Infection and inflammatory reaction due to other internal joint prosthesis**

ICD Code	Diagnosis
T84.620	Infection and inflammatory reaction due to internal fixation device of right femur
T84.621	Infection and inflammatory reaction due to internal fixation device of left femur
T84.622	Infection and inflammatory reaction due to internal fixation device of right tibia
T84.623	Infection and inflammatory reaction due to internal fixation device of left tibia
T84.69	Infection and inflammatory reaction due to internal fixation device of other site
T84.7	Infection and inflammatory reaction due to other internal orthopedic prosthetic devices, implants and grafts
T85.7	Infection and inflammatory reaction due to other internal prosthetic devices, implants and grafts
T85.79	Infection and inflammatory reaction due to other internal prosthetic devices, implants and grafts
Z47.3	**Aftercare following explantation of joint prosthesis**
Z47.33	**Aftercare following explantation of knee joint prosthesis**
Z86.14	Personal history of Methicillin resistant Staphylococcus aureus infection
	Fracture
M96.6	**Fracture of bone following insertion of orthopedic implant, joint prosthesis, or bone plate**
M96.66	**Fracture of femur following insertion of orthopedic implant, joint prosthesis, or bone plate**
M96.661	**Fracture of femur following insertion of orthopedic implant, joint prosthesis, or bone plate, right leg**
M96.662	**Fracture of femur following insertion of orthopedic implant, joint prosthesis, or bone plate, left leg**
M96.669	**Fracture of femur following insertion of orthopedic implant, joint prosthesis, or bone plate, unspecified leg**
M96.67	**Fracture of tibia or fibula following insertion of orthopedic implant, joint prosthesis, or bone plate**
M96.671	**Fracture of tibia or fibula following insertion of orthopedic implant, joint prosthesis, or bone plate, right leg**
M96.672	Fracture of tibia or fibula following insertion of orthopedic implant, joint prosthesis, or bone plate, left leg
M97.11	**Periprosthetic fracture around internal prosthetic right knee joint**
M97.12	**Periprosthetic fracture around internal prosthetic left knee joint**
M97.679	**Fracture of tibia or fibula following insertion of orthopedic implant, joint prosthesis,** or bone plate, unspecified
M97.8	**Periprosthetic fracture around other internal prosthetic joint**
M97.9	**Periprosthetic fracture around unspecified internal prosthetic joint**
S72	Fracture of femur
S72.301	Unspecified fracture of shaft of right femur
S72.332	Displaced oblique fracture of shaft of left femur
S72.341	Displaced spiral fracture of shaft of right femur
S72.361	Displaced segmental fracture of shaft of right femur
S72.40	Unspecified fracture of lower end of femur
S72.402	Unspecified fracture of lower end of left femur
S72.81	Other fracture of right femur
S72.89	Other fracture of unspecified femur for closed fracture
S82.001	Unspecified fracture of right patella
S82.002	Unspecified fracture of left patella
S82.012	Displaced osteochondral fracture of left patella
S82.031	Displaced transverse fracture of right patella for closed fracture
S82.091	Other fracture of right patella
S82.10	Unspecified fracture of upper end of tibia

ICD Code	Diagnosis
S82.101	Unspecified fracture of upper end of right tibia for open fracture type IIIA, IIIB, or IIIC
S82.102	Unspecified fracture of upper end of left tibia for open fracture type I or II
S82.152	Displaced fracture of left tibial tuberosity for open fracture type I or II
S82.191	Other fracture of upper end of right tibia
S82.192	Other fracture of upper end of left tibia
S82.201	Unspecified fracture of shaft of right tibia
S82.221	Displaced transverse fracture of shaft of right tibia
S82.222	Displaced transverse fracture of shaft of left tibia
S82.231	Displaced oblique fracture of shaft of right tibia for closed fracture
S82.241	Displaced spiral fracture of shaft of right tibia for closed fracture
S82.251	Displaced comminuted fracture of shaft of right tibia
S82.252	Displaced comminuted fracture of shaft of left tibia for open fracture type I or II
S82.261	Displaced segmental fracture of shaft of right tibia
S82.262	Displaced segmental fracture of shaft of left tibia
S82.291	Other fracture of shaft of right tibia
S82.292	Other fracture of shaft of left tibia
S82.872	Displaced pilon fracture of left tibia
S82.891	Other fracture of right lower leg
S82.92	Unspecified fracture of left lower leg
T84.042	**Periprosthetic fracture around internal prosthetic right knee joint**
T84.043	**Periprosthetic fracture around internal prosthetic left knee joint**
T84.048	**Periprosthetic fracture around other internal prosthetic joint**
T84.049	**Periprosthetic fracture around unspecified internal prosthetic joint**
	Instability
M22.00	Recurrent dislocation of patella, unspecified knee
M23.5	Chronic instability of knee
M23.50	Chronic instability of knee, unspecified knee
M23.51	Chronic instability of knee, right knee
M23.52	Chronic instability of knee, left knee
M24.30	Pathological dislocation of unspecified joint, not elsehwhere classified
M24.36	Pathological dislocation of knee, not elsewhere classified
M24.361	Pathological dislocation of right knee, not elsewhere classified
M24.362	Pathological dislocation of left knee, not elsewhere classified
M24.369	Pathological dislocation of unspecified knee, not elsewhere classified
M24.40	Recurrent dislocation, unspecified joint
M24.46	Recurrent dislocation, knee
M24.462	Recurrent dislocation, left knee
M24.469	Recurrent dislocation, unspecified knee
M25.3	Other instability of joint
M25.30	Other instability, unspecified joint
M25.359	Other instabilty, unspecified joint
M25.36	Other instability, knee

ICD Code	Diagnosis
M25.361	Other instability, right knee
M25.362	Other instability, left knee
M25.369	Other instability, unspecified knee
S83	Subluxation and dislocation of patella, sequela
S83.004	Unspecified dislocation of right patella
S83.104	Unspecified dislocation of right knee
S83.105	Unspecified dislocation of left knee
S83.115	Anterior dislocation of proximal end of tibia, left knee
T84.02	Dislocation of internal joint prosthesis
T84.022	Instability of internal right knee prosthesis
T84.023	Instability of internal left knee prosthesis
T84.028	Dislocation of other internal joint prosthesis
T84.029	Dislocation of unspecified internal joint prosthesis
M22.0	Recurrent dislocation of patella
M23.5	Chronic instability of knee
M24.30	Pathological dislocation of joint, not elsehwhere classified
M24.36	Pathological dislocation of knee, not elsewhere classified
M24.40	Recurrent dislocation, unspecified joint
M24.46	Recurrent dislocation, knee
M25.3	Other instability of joint
M25.30	Other instability, unspecified joint
M25.36	Other instability, knee
S83.00	Unspecified subluxation and dislocation of patella
S83.10	Unspecified subluxation and dislocation of knee
S83.11	Anterior subluxation and dislocation of proximal end of tibia
T84.02	**Dislocation of internal joint prosthesis**
T84.022	**Instability of internal right knee prosthesis**
T84.023	**Instability of internal left knee prosthesis**
T84.028	**Dislocation of other internal joint prosthesis**
T84.029	**Dislocation of unspecified internal joint prosthesis**
	Loosening
T84.03	**Mechanical loosening of internal prosthetic joint**
T84.032	**Mechanical loosening of internal right knee prosthetic joint**
T84.033	**Mechanical loosening of internal left knee prosthetic joint**
T84.038	**Mechanical loosening of other internal prosthetic joint**
T84.039	**Mechanical loosening of unspecified internal prosthetic joint**
T84.428	Displacement of other internal orthopedic devices, implants and grafts, initial encounter
T85.628	Displacement of other specified internal prosthetic devices, implants and grafts, initial encounter

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Table 1.

Performance of Each Query Method by Diagnosis Category

Query Method	% Agreement	Kappa* (95% CI)	Sensitivity	Specificity	PPV	NPV
PJI						
PS-PD	89.3%	0.51 (0.43–0.58)	38.6%	99.9%	98.5%	88.6%
AR-PD	97.5%	0.91 (0.87–0.94)	86.0%	99.9%	99.3%	97.1%
PS-AD	90.4%	0.58 (0.50–0.65)	45.6%	99.8%	97.5%	89.8%
AR-AD	97.3%	0.90 (0.87–0.94)	88.3%	99.1%	95.6%	97.6%
Loosening						
PS-PD	82.1%	0.64 (0.59–0.69)	69.7%	94.8%	93.2%	75.4%
AR-PD	82.1%	0.64 (0.59–0.69)	69.7%	94.8%	93.2%	75.4%
PS-AD	82.5%	0.65 (0.60–0.70)	70.9%	94.3%	92.7%	76.1%
AR-AD	82.4%	0.65 (0.60–0.70)	70.9%	94.1%	92.4%	76.0%
Instability						
PS-PD	82.9%	0.59 (0.54–0.65)	56.8%	97.5%	92.8%	80.1%
AR-PD	82.7%	0.59 (0.53–0.65)	56.8%	97.3%	92.2%	80.1%
PS-AD	84.8%	0.64 (0.59–0.70)	62.2%	97.5%	93.3%	82.2%
AR-AD	84.7%	0.64 (0.59–0.70)	62.9%	96.9%	92.0%	82.4%
Fracture						
PS-PD	97.1%	0.24 (0.04–0.44)	16.0%	99.6%	57.1%	97.4%
AR-PD	97.1%	0.24 (0.04–0.44)	16.0%	99.6%	57.1%	97.4%
PS-AD	97.1%	0.36 (0.16–0.55)	28.0%	99.2%	53.9%	97.8%
AR-AD	97.1%	0.36 (0.16–0.55)	28.0%	99.2%	53.9%	97.8%

PS-PD: Prosthetic joint-specific diagnosis codes in the principal diagnosis position; AR-PD: Any related code in the principal diagnosis position; PS-AD: Prosthetic joint-specific diagnosis codes in any of the 10 diagnostic positions; AR-AD: Any related code in any of the 10 diagnostic positions

*Cohen's kappa statistic was calculated and was assessed using grading criteria per precedence in the literature: κ = 0.20 to 0.39, fair; κ = 0.40 to 0.59, moderate; κ = 0.60 to 0.79, very good; κ greater than 0.80, excellent