

# Causes and Rates of Unplanned Readmissions After Elective Primary Total Joint Arthroplasty: A Systematic Review and Meta-Analysis

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## Abstract

To address the lack of consensus on the leading reasons for readmissions after primary elective unilateral total joint arthroplasties (TJAs), we performed a systematic review and a meta-analysis to identify overall and cause-specific readmission rates.

We performed structured searches of the Medline and Cochrane databases for original reports—published between January 1982 and January 2013—on both 30- and 90-day follow-ups of unique patient populations that underwent elective primary TJA. Random-effects meta-analyses were performed to obtain pooled estimates.

For total hip arthroplasty (THA), the overall pooled readmission rate was 5.6% at 30 days and 7.7% at 90 days. For total knee arthroplasty (TKA), the overall rate was 3.3% at 30 days and 9.7% at 90 days. The leading reason for THA readmission was joint-specific at both 30 and 90 days, and the leading reason for TKA readmission was surgical site infection.

Our systematic review and meta-analysis established baseline readmission rates in the literature on primary TJA and identified the most common reasons driving readmission for TJA.

Since 2005, the cost of THA has risen more than 4 times, to \$13.43 billion, and the cost of TKA has risen more than 5 times, to \$40.8 billion.<sup>8,9</sup> Given the demand and price tag, TJA is the single largest cost in the Medicare budget.<sup>10</sup>

Given its potential to improve care and reduce costs, reducing readmission rates in the surgical setting is a priority for physicians and policymakers.<sup>11</sup> Readmissions for TJA are highly scrutinized as a performance indicator—the Centers for Medicare & Medicaid Services (CMS) started including them in its readmissions penalty program in 2013—and were recently validated as a measure of surgical quality.<sup>12-14</sup> Accurate assessments of readmissions after TJA are unclear, with rates ranging from 1% to 8.5% between 7 and 90 days after surgery.<sup>2,15-17</sup> The early success of TJA as an elective (and more frequently outpatient) procedure has paradoxically translated to less tolerance for readmissions. Post-TJA complications resulting in readmission are subject to financial penalties, and there is an implicit judgment of inadequate surgical management.<sup>12</sup>

Not only is the readmission rate poorly characterized, but there is no consensus on the leading reasons for readmissions after primary elective unilateral TJAs. The range of rates, reasons, and follow-up periods reported in the literature is wide.<sup>18,19</sup> CMS plans to monitor readmissions over 7 to 90 days after surgery (the period depends on the complication), whereas a significant portion of the orthopedic literature documents 90-day rates.<sup>19</sup> In 2012, the Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation prepared for CMS a comprehensive report identifying rates of post-TJA complications and readmissions.<sup>20</sup> The report, however, is limited to US hospitals and Medicare patients and therefore may overstate the rates, given this population's documented comorbidities and the reimbursement variations between Medicare and commercial insurance.<sup>21</sup> Lack of consensus on readmissions after primary elective unilateral TJAs requires that we synthesize available data to answer several questions: What is the overall readmission rate 30 and 90

Total joint arthroplasty (TJA) is a clinically effective, cost-effective treatment for symptomatic arthritis.<sup>1,2</sup> After TJA, patients report reduced pain, restored range of motion, high satisfaction, and ability to return to a more active lifestyle.<sup>3-7</sup> The number of total hip arthroplasties (THAs) performed in the United States is expected to reach 572,000 by 2030, a 174% increase, and the number of total knee arthroplasties (TKAs) 3.5 million, nearly a 7-fold increase.<sup>8,9</sup>

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**Table 1. Diagnoses Associated With Each Reason for Readmission Classification**

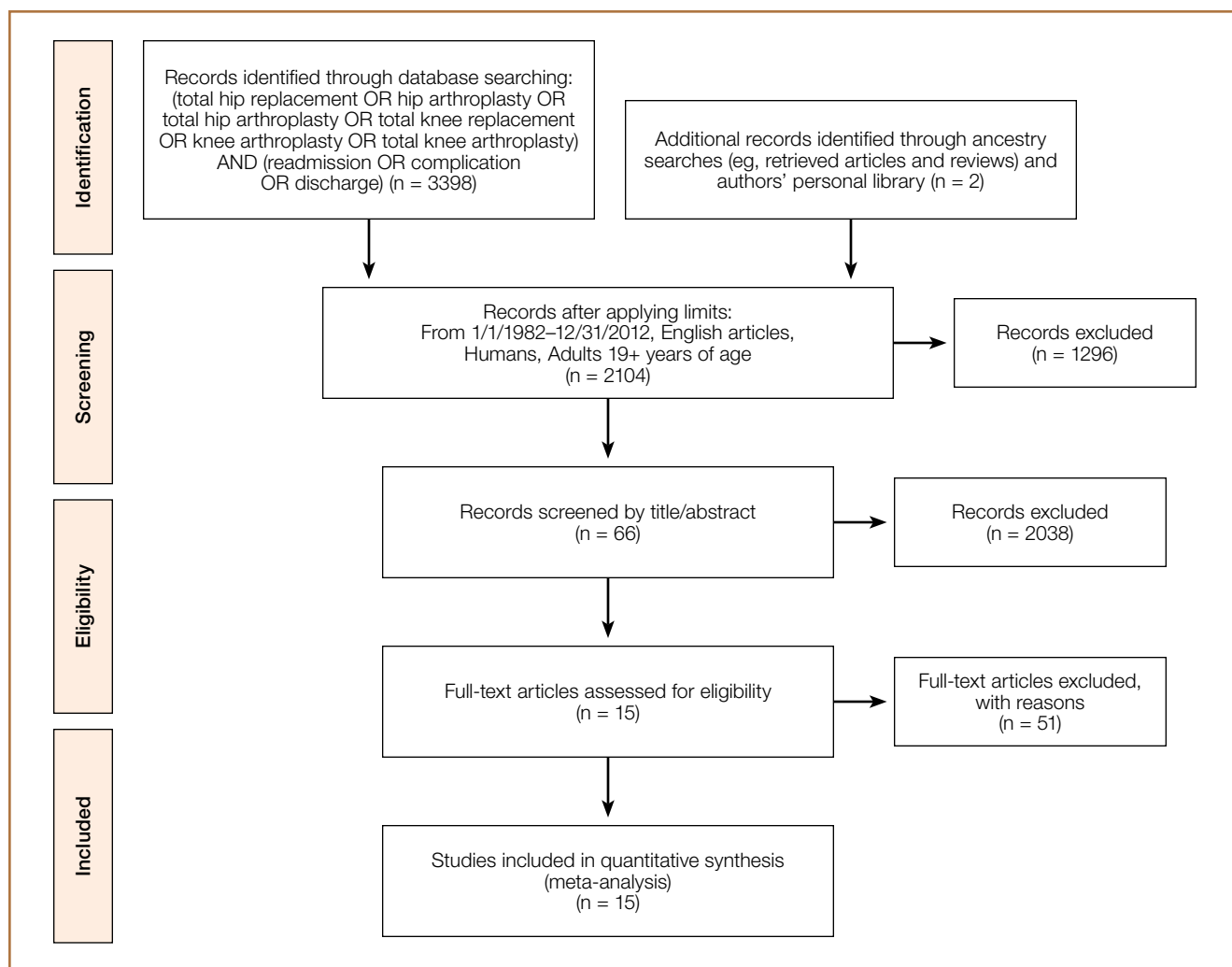
Thromboembolic Disease	Joint-Specific	Sequelae	Cardiac Dysrhythmia	Surgical Site Infection
Deep vein thrombosis	Traumatic and atraumatic dislocation	Postoperative pain	Arrhythmia	Superficial infection
Pulmonary embolism	Prosthetic misalignment	Poor mobilization	Exacerbation of	Deep infection
Thromboembolic disorder	Ligamentous laxity	Falling episodes	congestive heart	
	Periprosthetic fracture	Anemia and dizziness	failure	
	Septic joint, periprosthetic infection, or both	Hematoma		

days after TJA? What are the primary reasons for readmission 30 and 90 days after TJA? What are the cause-specific readmission rates? We performed a systematic review and a meta-analysis to answer these questions and to add clarity to the literature in order to help guide policy.

**Materials and Methods**

We performed a systematic review in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and

Meta-Analyses) guidelines.<sup>22</sup> Two reviewers independently completed structured searches of the Medline and Cochrane Central Register of Controlled Trials databases. Search terms were: (total hip replacement OR hip arthroplasty OR total hip arthroplasty OR total knee replacement OR knee arthroplasty OR total knee arthroplasty) AND (readmission OR complication OR discharge). They updated the search June 1, 2013. Four limits were applied: publication between January 1, 1982 and December 12, 2012; human subjects only; age 19+ years; and English-language articles. Study eligibility



**Figure 1.** PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram of search methodology and application of inclusion and exclusion criteria for primary unilateral total hip arthroplasty.

was determined by using standardized criteria as defined by the inclusion and exclusion criteria described in 3 stages: title review, abstract review, and full-article review. The reviewers

also performed ancestry searches, including searches for major review articles and bibliographies of all retrieved studies, to identify additional studies not identified in the keyword

**Table 2. Eligible Total Hip Arthroplasty Studies**

Study	Year	Study Design	Evidence Level	Patients, N	Data Source	Unplanned Readmission Rate, %	Follow-Up, d
Bjørnarå et al <sup>35</sup>	2006	Retrospective review of medical records at Buskerud Hospital and University College	III	2512	Buskerud Hospital and University College, Buskerud, Norway; Thrombosis Research Institute, London, UK	N/A <sup>a</sup>	30
CMS, 30 days <sup>20</sup>	2012	Retrospective review of 3083 US hospitals	III	97,130	Medicare Parts A and B (2008–2010)	6.9% (6702/97,130)	30
CMS, 90 days <sup>20</sup>	2012	Retrospective review of 3083 US hospitals	III	97,130	Medicare Parts A and B (2008–2010)	12.2% (11,850/97,130)	90
Cullen et al <sup>32</sup>	2006	Retrospective review of Stepping Hill Hospital database	III	769	Department of Trauma and Orthopaedics and Clinical Effectiveness Unit, Stepping Hill Hospital, Stockport, UK	8.4% (65/769)	30
Husted et al <sup>25</sup>	2010	Retrospective review of a national health registry in Denmark	III	947	Department of Orthopedic Surgery, Hvidovre University Hospital, Copenhagen, Denmark	10.9% (103/947)	90
Keeney et al <sup>26</sup>	2012	Retrospective review of medical records in St. Louis, MO	III	2689	Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, MO	3.8% (101/2689)	90
Kreder et al <sup>30</sup>	1997	Retrospective review of Washington state discharge registry	III	7936	Comprehensive Hospital Abstract Reporting System (CHARS), Washington State Department of Health	4.7% (183/3890)	90
Mahomed et al <sup>31</sup>	2003	Retrospective review of Medicare claims	II	61,568	Toronto Western Hospital, Toronto, Canada	4.6% (2832/61,568)	90
Saucedo et al, <sup>27</sup> 30 days	2013	Retrospective review of Northwestern Hospital System medical records in Feinberg School of Medicine	III	2524	Department of Orthopaedic Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL	3.4% (86/2524)	30
Saucedo et al, <sup>27</sup> 90 days	2013	Retrospective review of Northwestern Hospital System medical records in Feinberg School of Medicine	III	2524	Department of Orthopaedic Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL	7.2% (182/2524)	90
Seagroatt et al <sup>28</sup>	1991	Retrospective review of Oxford, UK Regional Health Authority	II	7547	Unit of Clinical Epidemiology, Department of Public Health and Primary Care, University of Oxford, Oxford, UK	2.8% (208/7547)	30
Vorhies et al <sup>33</sup>	2011	Retrospective review of Medicare Patient Safety Monitoring System database	III	1802	Department of Orthopaedic Surgery, Stanford University Medical Center, Stanford, CA; Department of Orthopaedic Surgery, Massachusetts General Hospital, Boston, MA	6.8% (123/1802)	30
Warwick et al <sup>29</sup>	1995	Retrospective review of Avon Orthopaedic Centre in Bristol, UK	III	1112	University of Bristol, Bristol, UK	N/A <sup>a</sup>	30
White et al <sup>34</sup>	1998	Retrospective review of California discharge database	III	19,586	Department of Orthopaedic Surgery, Department of Statistics, and Division of General Medicine, University of California Davis Medical Center, Sacramento, CA	N/A <sup>a</sup>	90

Abbreviations: CMS, Centers for Medicare & Medicaid Services; N/A, not applicable.

<sup>a</sup>Study reviewed only patients readmitted for thromboembolic diseases; total readmission rates not reported.

searches. Discrepancies were resolved by author consensus.

Inclusion criteria were original studies that presented level I to III evidence and that were identified in structured online searches; published in English between January 1, 1982 and December 31, 2012; involved patients older than 19 years; and reported both readmission rates and reasons at follow-up 30 or 90 days after elective primary unilateral TJA, regardless of indi-

cation. Exclusion criteria were studies that reported data from hip fracture, knee fracture, and pelvis fracture cases; those that reported data from hemiarthroplasty, Birmingham hip resurfacing procedures, other resurfacing procedures, simultaneous bilateral hip or knee arthroplasties, unicompartmental knee arthroplasty, patellofemoral arthroplasty, metastatic or bone cancer, or revision hip or knee arthroplasty; those that did not report extractable reasons for readmission; those that reported complications but did not specify readmission rates; and those that reported readmission data only from after the 90-day follow-up window. In cases in which multiple studies reported data from the same patient population, only the largest or most recent report was used.

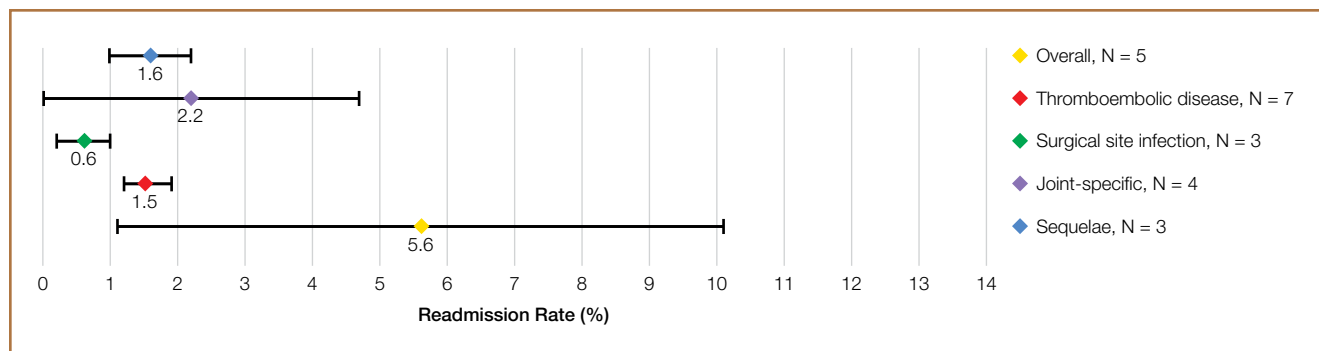
Two reviewers extracted the quantitative data from eligible studies. The 2 primary outcomes of interests were all-cause readmission rates, and reasons for readmission 30 and 90 days after TJA. Other extracted data were evidence level; publication journal, year, and country; data source (academic institution, Medicare); study design; number of patients; patient characteristics; surgical approach; follow-up period; overall readmission rate; anticoagulant use; tourniquet use; and compression stocking use. In addition, all post-TJA readmissions were assumed to be unplanned, except for staged sequential bilateral arthroplasty for osteoarthritis (excluded from analysis).

Readmission reasons were divided into 4 major categories as defined by the literature and the authors: thromboembolic

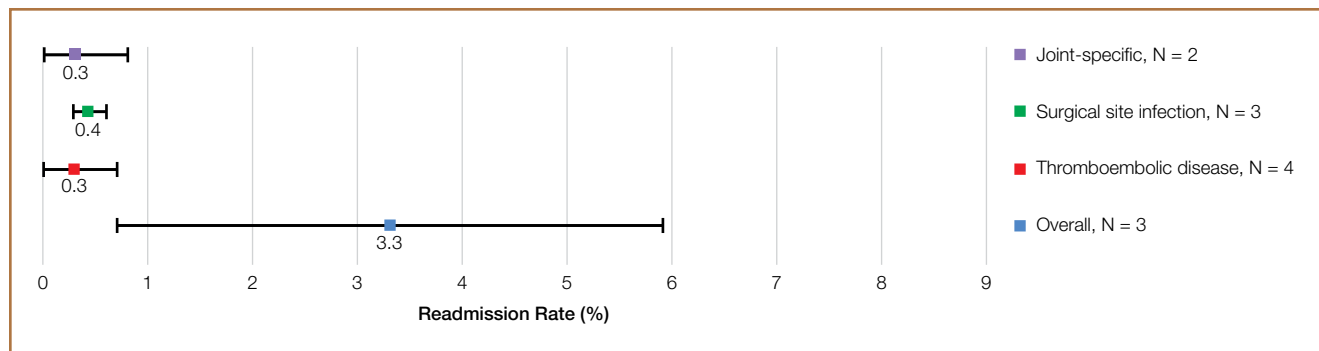
**Table 3. Number of Total Hip Arthroplasty Studies That Reported Certain Characteristics**

Characteristic	Studies, n (of 12)
Sex	3
Ethnicity	3
Age	6
Anticoagulation	5
Compression stockings	4
Tourniquet use	1
Surgical approach	1
Superficial vs deep wound infection	2 (59% superficial, 41% deep) <sup>a</sup>

<sup>a</sup>Only 2 studies (Husted et al,<sup>28</sup> Cullen et al<sup>29</sup>) reported delineation between superficial and deep infection, among total of 17 readmitted patients.



**Figure 2.** Overall and cause-specific total hip arthroplasty readmission rates at 30-day follow-up. N, number of studies that reported rates.



**Figure 3.** Overall and cause-specific total knee arthroplasty readmission rates at 30-day follow-up. N, number of studies that reported rates.

disease, joint-specific reasons, surgical site infection, and surgical sequelae. The diagnoses in these categories are listed in **Table 1**. Other extracted reasons were cardiac dysrhythmia and pneumonia.

In cases in which there were at least 2 comparable studies, a meta-analysis was performed to obtain pooled estimates of the proportion of patients readmitted at 30 or 90 days. We calculated a Higgins  $I^2$  measure for between-study heterogeneity and random-effects analysis, using the method of DerSimonian and Laird<sup>23</sup> if  $I^2$  was greater than 0.5. Pooled estimates were obtained for both overall and cause-specific reasons for readmission for all reasons reported in at least 3

studies. Small-study or publication bias was assessed using funnel plot asymmetry when at least 5 studies were analyzed as recommended.<sup>24</sup> The meta-analytic findings for both overall and cause-specific readmission are presented as pooled proportions with 95% confidence intervals (CIs). All meta-analyses were performed using Stata 10.0.

## Results

Fifteen unique TJA studies (12 THA, 10 TKA) met the criteria for the meta-analysis.<sup>20,25-38</sup> **Figure 1** depicts the PRISMA flow-chart for study identification.<sup>22</sup>

Of the 12 studies eligible for the THA analysis (**Table 2**),

**Table 4. Eligible Total Knee Arthroplasty Studies**

Study	Year	Study Design	Evidence Level	Patients, N	Data Source	Unplanned Readmission Rate, %	Follow-Up, d
Berger et al <sup>36</sup>	2009	Prospective study of Rush Medical College database	II	80	Department of Orthopaedic Surgery, Rush Medical College, Chicago, IL	10% (8/80)	90
Bjørnaraå et al <sup>35</sup>	2006	Retrospective review of medical records at Buskerud Hospital and University College	III	675	Buskerud Hospital and University College, Buskerud, Norway; Thrombosis Research Institute, London, UK	N/A <sup>a</sup>	30
CMS, 90 days <sup>20</sup>	2012	Retrospective review of 3083 US hospitals	III	240,517	Medicare Parts A and B (2008–2010)	10.7% (25,735/240,517)	90
Cram et al <sup>37</sup>	2012	Retrospective review of Medicare administrative database	III	3,271,851	Medicare Part A	4.4% (145,083/3,271,851)	30
Husted et al <sup>25</sup>	2010	Retrospective review of a national health registry in Denmark	III	784	Department of Orthopedic Surgery, Hvidovre University Hospital, Copenhagen, Denmark	15.56% (122/784)	90
Keeney et al <sup>26</sup>	2012	Retrospective review of medical records in St. Louis, MO	III	2190	Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, MO	5.6% (122/2190)	90
Saucedo et al <sup>27</sup> 30 days	2013	Retrospective review of Northwestern Hospital System medical records in Feinberg School of Medicine	III	3890	Department of Orthopaedic Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL	4.7% (183/3890)	30
Saucedo et al <sup>27</sup> 90 days	2013	Retrospective review of Northwestern Hospital System medical records in Feinberg School of Medicine	III	3890	Department of Orthopaedic Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL	8.2% (319/3890)	90
Seah et al <sup>38</sup>	2007	Retrospective review of Singapore institutional database (ARSKR, OTMS, ISD, QMMD)	III	2219	Department of Orthopaedic Surgery, Singapore General Hospital, Singapore	0.77% (17/2219)	30
Warwick et al <sup>29</sup>	1995	Prospective study of UK regional database	II	991	University of Bristol and Bristol Knee Group, Bristol, UK	N/A <sup>a</sup>	90
White et al <sup>34</sup>	1998	Retrospective review of California discharge database	III	24,059	Department of Orthopaedic Surgery, Department of Statistics, and Division of General Medicine, University of California Davis Medical Center, Sacramento, CA	N/A <sup>a</sup>	90

Abbreviations: ARSKR, Adult Reconstructive Service Knee Registry; CMS, Centers for Medicare & Medicaid Services; ISD, Internal Security Department; N/A, not applicable; OTMS, Operating Theatre Management System; QMMD, Quality Management Morbidity Database.

<sup>a</sup>Study reviewed only patients readmitted for thromboembolic diseases; total readmission rates not reported.

6 were conducted in the United States,<sup>20,26,27,30,33,34</sup> 5 in Europe,<sup>25,28,29,32,35</sup> and 1 in Canada.<sup>31</sup> Seven of the 12 studies reported readmission rates at 30 days, and 7 reported rates at 90 days (2 reported rates at both follow-ups). We analyzed a total of 113,396 patients at the 30-day window and 192,380 patients at the 90-day window. Mean age was 74.2 years. The

included studies were variable and sparse in their reporting of specific characteristics (Table 3).

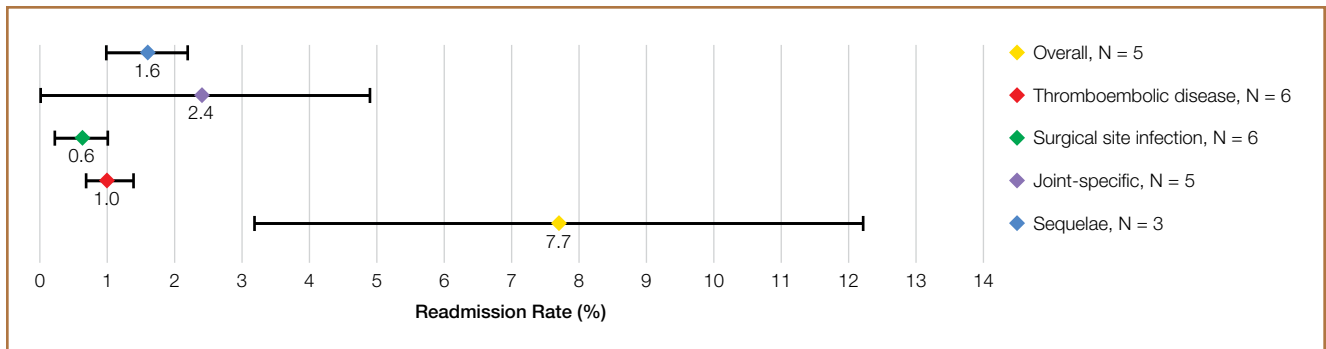
Of the 10 studies (2 prospective, 8 retrospective) eligible for the TKA analysis (Table 4), 6 were conducted in the United States,<sup>20,26,27,34,36,37</sup> 3 in Europe,<sup>25,29,35</sup> and 1 in Asia.<sup>38</sup> Four of the 10 studies reported readmission rates at 30 days, and 7 reported rates at 90 days (1 reported rates at both follow-ups).<sup>27</sup> We analyzed a total of 3,278,635 patients at the 30-day window and 272,419 patients at the 90-day window. Mean age was 74.3 years. The included studies were quite variable and sparse in their reporting of specific characteristics (Table 5).

We performed random-effects meta-analyses of all unplanned readmissions at both 30 and 90 days (all  $I^2 > 0.5$ ). Among 5 THA studies that reported overall rates at 30 days,<sup>20,27,28,32,33</sup> the estimated overall unplanned rate among the 120,272 index surgeries was 5.6% (95% CI, 3.2%-8.0%). Among 5 THA studies that reported overall rates at 90 days,<sup>20,25-27,31</sup> the estimated overall unplanned rate among the 192,380 index surgeries was 7.7% (95% CI, 3.2%-12.2%) ( $I^2 = 1.00$ ). Among 3 TKA studies that reported overall rates at 30 days,<sup>27,37,38</sup> the estimated overall unplanned rate among the 3,278,635 index surgeries was 3.3% (95% CI, 0.7%-5.9%). Among 5 TKA studies that reported overall rates at 90 days,<sup>20,25-27,36</sup> the estimated overall unplanned rate among the 272,419 index surgeries was 9.7% (95% CI, 7.1%-12.4%) ( $I^2 = 0.97$ ).

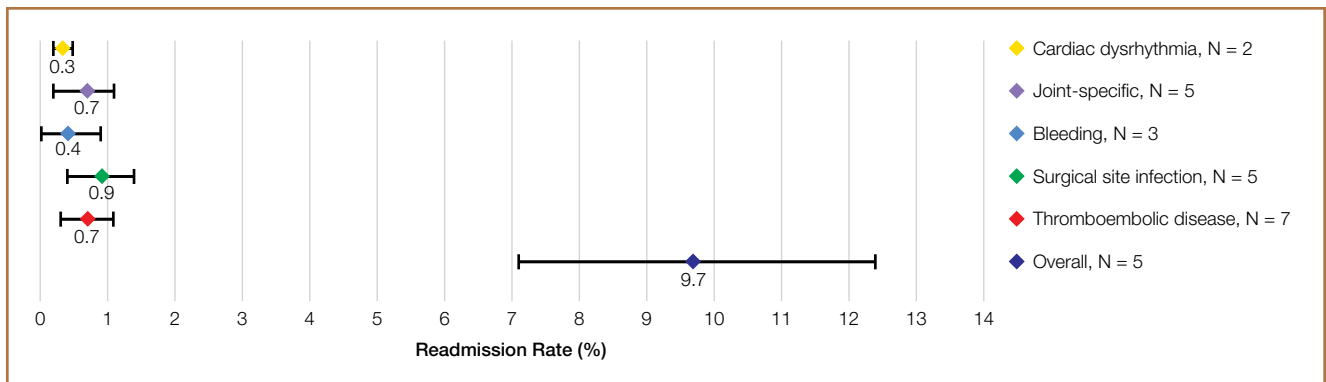
**Table 5. Number of Total Knee Arthroplasty Studies That Reported Certain Characteristics**

Characteristic	Studies, n (of 10)
Sex	3
Ethnicity	2
Age	9
Anticoagulation	5
Compression stockings	2
Tourniquet use	2
Surgical approach	2
Superficial vs deep wound infection	2 (52% superficial, 48% deep) <sup>a</sup>

<sup>a</sup>Only 2 studies (Husted et al,<sup>28</sup> Seah et al<sup>38</sup>) reported delineation between superficial and deep infection, among total of 31 readmitted patients.



**Figure 4.** Overall and cause-specific total hip arthroplasty readmission rates at 90-day follow-up. N, number of studies that reported rates.



**Figure 5.** Overall and cause-specific total knee arthroplasty readmission rates at 90-day follow-up. N, number of studies that reported rates.



### 30-Day Readmission Rates

The most common reason for readmission 30 days after THA discharge was joint-specific. This reason accounted for 39.3% of all unplanned readmissions among studies that reported joint-specific causes, with an estimated pooled rate of 2.2% (95% CI, 0.0%-4.6%;  $P < .001$ ;  $I^2 = 1.00$ ) among 4 studies. The second and third most common reasons were surgical sequelae (1.6%; 95% CI, 0.8%-2.5%;  $P < .001$ ;  $I^2 = 0.95$ ) and thromboembolic disease (1.5%; 95% CI, 1.0%-1.9%;  $P < .001$ ;  $I^2 = 0.95$ ). See **Figure 2** for 30-day THA readmission rates. The fourth most common readmission reason was surgical site infection (0.6%; 95% CI, 0.2%-1.1%;  $P < .001$ ;  $I^2 = 0.94$ ). Only these 4 reasons could be pooled, as cardiac dysrhythmia, pneumonia, and bleeding were reported in only 1 study each.

The most common reason for readmission 30 days after TKA discharge was surgical site infection. This reason accounted for 12.1% of all unplanned readmissions among studies that reported surgical site infections, with an estimated pooled rate of 0.4% (95% CI, 0.3%-0.6%;  $P < .001$ ;  $I^2 = 0.61$ ) among 3 studies. The second and third most common reasons were joint-specific and thromboembolic disease, both occurring 0.3% of the time. Joint-specific reasons were reported in 2 studies (95% CI, 0.0%-0.8%;  $P = .259$ ;  $I^2 = 0.94$ ). Thromboembolic disease was reported in 4 studies (95% CI, 0.0%-0.7%;  $P = .067$ ;  $I^2 = 0.98$ ) (**Figure 3**). Only these 3 reasons could be pooled, as cardiac dysrhythmia, pneumonia, and “sequelae” were reported in only 1 study each.

### 90-Day Readmission Rates

Consistent with the 30-day THA results, the most common reason for readmission 90 days after THA discharge was joint-specific. This reason accounted for 31.2% of all unplanned readmissions among studies that reported joint-specific causes, with an estimated pooled rate of 2.4% (95% CI, 0.0%-4.9%;  $P < .001$ ;  $I^2 = 1.00$ ) among 5 studies. The second and third most common reasons were surgical sequelae (1.6%; 95% CI, 1.0%-2.2%;  $P < .003$ ;  $I^2 = 0.83$ ) and thromboembolic disease (1.0%; 95% CI, 0.7%-1.4%;  $P < .001$ ;  $I^2 = 0.97$ ). See **Figure 4** for 90-day THA readmission rates. The fourth most common readmission reason was surgical site infection (0.6%; 95% CI, 0.2%-1.0%;  $P < .001$ ;  $I^2 = 0.99$ ). Only these 4 reasons could be pooled, as cardiac dysrhythmia, pneumonia, and bleeding were reported by only 1 study each.

Consistent with the 30-day TKA results, the most common reason for readmission 90 days after TKA discharge was surgical site infection. This reason accounted for 9.3% of all unplanned readmissions among studies that reported surgical site infections, with an estimated pooled rate of 0.9% (95% CI, 0.4%-1.4%;  $P < .001$ ;  $I^2 = 0.93$ ) among 5 studies. The second and third most common reasons were joint-specific and thromboembolic disease, both occurring 0.7% of the time. Joint-specific reasons were reported in 5 studies (95% CI, 0.2%-1.1%;  $P = .003$ ;  $I^2 = 0.94$ ). Thromboembolic disease was reported in 7 studies (95% CI, 0.3%-1.1%;  $P < .001$ ;  $I^2 = 0.97$ ) (**Figure 5**). Bleeding was reported in 3 studies, with a pooled rate of 0.4% (95% CI, 0.0%-0.9%;  $P = .128$ ;  $I^2 = 0.83$ ). Cardiac

dysrhythmia was reported in 2 studies, with an estimated pooled rate of 0.3% (95% CI, 0.2%-0.5%;  $P < .001$ ). Only these 5 reasons could be pooled, as pneumonia and “sequelae” were reported in only 1 study each.

### Discussion

This study is the first systematic review and meta-analysis of the literature to identify overall and cause-specific readmission rates after TJA.

For THA, 30- and 90-day readmission rates were 5.6% and 7.7%, respectively. Joint-specific causes were the most common reason for readmission at both 30 and 90 days after THA. For TKA, 30- and 90-day rates were 3.3% and 9.7%, respectively. Surgical site infection was the most common reason for readmission at both 30 and 90 days after TKA.

Hospital readmissions are an important area of scrutiny for Medicare and the health care systems broadly. Readmissions after surgery are deemed quality indicators potentially suggesting incomplete management of active issues and inadequate preparation for discharge.<sup>39</sup> Unplanned readmissions also place a significant economic burden on Medicare: \$17.5 billion in 2010.<sup>40</sup> Given their association with quality of overall surgical care, improved readmission rates have the potential to improve the standard of care and reduce costs.

Higher readmission rates will significantly affect hospitals as CMS shifts to bundling payments for acute-care episodes, such as TJA.<sup>41-43</sup> Further, private and public health care payers are increasingly using unplanned 30- and 90-day readmission rates as a marker of quality of care. However, there is little agreement about readmission rates and reasons, let alone what follow-up window should be used to define orthopedic readmissions. One study involving the MEDPAR (Medicare Provider Analysis and Review) database found that a common reason for readmission after major hip or knee surgery was “aftercare” for surgical sequelae (10.3%)<sup>15</sup>; another study found a 15% increase in post-THA hospitalizations, most commonly for a mechanical complication (joint-related).<sup>44</sup> There are no prior complete systematic reviews or meta-analyses of overall rates of readmissions after primary unilateral TJAs, or of the reasons for these readmissions. The closest such report, the Yale report to CMS, was skewed to a proportion of US hospitals treating a population prone to significant comorbidities.<sup>20</sup>

Although the strength of this study lies in its rigorous identification and extraction of data, notable clarifications must be made when synthesizing the information. First, the definitions of various thromboembolic events varied greatly. Some studies reported deep vein thrombosis (DVT) and pulmonary embolism (PE) separately, whereas others reported only DVT or only PE. Some studies reported rates of readmission for “thromboembolic disorder,” and one<sup>25</sup> reported rates for DVT, PE, and thromboembolic disorder. To pool these related events, we created a composite definition that included DVT, PE, and thromboembolic disorders, which we termed *thromboembolic disease*. We also created a composite measure for joint-specific reasons for readmission. This category included joint infection that definitely required reentry into the joint, but using

this category may have led to underestimation of surgical site infection rates, which were defined separately. Third, there was significant variation in documentation of surgical site infection among the studies included in this review. Some studies specified superficial wounds, whereas others did not categorize complications as superficial, deep, or intracapsular, which would qualify as a “joint-specific” cause. Despite this variation, surgical site infection after TJA was found to be the most common reason for readmission.

Our systematic review and meta-analysis were limited, as any others are, by the quality of studies investigated. Few studies reported cause-specific rates and reasons for readmission. Given the small sample, formal tests for small-study or publication bias could not be performed. Some studies included tremendous amounts of data, and *International Classification of Diseases, Ninth Revision (ICD-9)* codes were used without physician review of readmission diagnoses. In the absence of oversight, many readmissions could have been misinterpreted and incorrectly logged, or simply miscoded. Saucedo and colleagues<sup>27,45</sup> found that readmission diagnostic codes were often unverified. Numerous other studies corroborated this lack of correlation with physician-derived readmission diagnoses in just 25% of cases.<sup>46-54</sup> Another study limitation is the unknown number of patients who had TJA but presented and were subsequently readmitted to a different hospital. Last, as this review included patients who had surgery performed within a 30-year period, it could not address the shifts in postoperative management that occurred in that time, particularly with respect to anticoagulation. This limitation was partially addressed in THA by dividing final studies into 3 decades. Of these studies, only 1 was from the first decade, 3 were from the second, and the rest were from the third. Of the 3 from the second decade, only the study by Warwick and colleagues<sup>29</sup> (1995) explicitly did not use anticoagulation, but compression stockings were used, and consequently there was a 4.0% rate of readmission for thromboembolic disease alone, compared with the study by White and colleagues<sup>34</sup> (1998), which explicitly used anticoagulation and boasted a 1.7% rate of readmission for thromboembolic disease. This isolated comparison illustrates the effect of routine anticoagulation and the changes in surgical standards over the 3 decades.

The numbers from this systematic review and meta-analysis represent an international benchmark for TJA as a procedure. Knowing the top reasons for readmission will lead to more focus on joint-related and medical issues (surgical site infection, thromboembolic disease) before discharge to avoid readmission after elective unilateral primary TJA. Although readmission rates have received attention in the United States as a primary means of combating soaring health care costs, knowing the rates for a common procedure applies broadly as an indicator for standard of care worldwide, according to the World Health Organization.<sup>55</sup> This study is the first systematic review and meta-analysis of documented readmission rates and reasons for readmission to identify overall and cause-specific rates after TJA. The hope is that our findings will add clarity to the literature and help guide the decisions of physicians and policymakers.

## Conclusion

Readmission rates are an increasingly important metric in the United States and around the world, yet there is no consensus regarding overall readmission rates and reasons for readmission after primary unilateral TJAs. Our systematic review and meta-analysis of the literature found overall unplanned readmission rates of 5.6% (30 days) and 7.7% (90 days) for THA and 3.3% (30 days) and 9.7% (90 days) for TKA. At both 30 and 90 days, the most common readmission reasons were joint-specific (THA) and surgical site infection (TKA). New investigations should be directed toward developing countermeasures to lower the rates of readmission.

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