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Current Risk Adjustment and Comorbidity Index Underperforms in Predicting Post-Acute Utilization and Hospital Readmissions after Joint Replacements: Implications for Comprehensive Care for Joint Replacement Model

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Abstract

Objective—Compare the performances of comorbidity indices: Charlson, Elixhauser, and the Centers for Medicare & Medicaid Services (CMS) risk adjustment model Hierarchical Condition Category (HCC), in predicting post-acute discharge settings and hospital readmission for patients after joint replacement.

Methods—Retrospective study of Medicare beneficiaries with total knee replacement (TKR) or total hip replacement (THR) discharged from hospitals in 2009–2011 (N=607,349). Study outcomes were post-acute discharge setting and unplanned 30-, 60-, and 90-day hospital readmissions. Logistic regression models were built to compare the performance of the three comorbidity indices using *C*-statistics. The base model included patient demographics and hospital use. Subsequent models included one of the three comorbidity indices. Additional multivariable

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logistic regression models were built to identify individual comorbid conditions associated with high risk of hospital readmissions.

Results—The 30-, 60-, and 90-day unplanned hospital readmission rates were 5.3%, 7.2%, and 8.5% respectively. Patients were most frequently discharged to home health (46.3%) followed by skilled nursing facility (40.9%) and inpatient rehabilitation facility (12.7%). The *C*-statistic for the base model in predicting post-acute discharge setting and 30-, 60-, and 90-day readmission in TKR and THR were between 0.63 and 0.67. Adding Charlson, Elixhauser or HCC increased the *C*-statistic minimally from the base model for predicting both discharge settings and hospital readmission. The health conditions most frequently associated with hospital readmission were diabetes, pulmonary disease, arrhythmias, and heart disease.

Conclusion—The comorbidity indices and CMS-HCC demonstrated weak discriminatory ability to predict post-acute discharge settings and hospital readmission following joint replacement.

INTRODUCTION

Osteoarthritis (OA) is one of the most common causes of disability [1]. Approximately 65% of lower extremity joint replacement procedures performed in the United States (US) are due to underlying degenerative joint conditions, including OA [1, 2]. A total of 321,005 total hip replacements (THR) and 640,695 total knee replacements (TKR) were performed in 2013 [2]. Patients who receive a joint replacement often have other comorbid conditions, which can negatively impact health outcomes and complicate the management of care. For example, the presence of diabetes, obesity, or postoperative infections are associated with higher hospital readmission rates in patients with joint replacements [3, 4] and increased in healthcare cost.

The Centers for Medicare & Medicaid Services (CMS) initiated the Hospital Readmission Reduction Program (HRRP) and more recently introduced the Comprehensive Care for Joint Replacement (CJR) program to reduce readmission rates and improve the transition of care after lower extremity joint replacement [5, 6]. In the current CJR model, hospitals are responsible for providing health services for an episode of acute, post-acute and outpatient care for up to 90 days [6]. Hospitals are incentivized (penalized) based on their performance on quality measures over 90-day episodes of care. Such proposed plans do not take into account patient level complexity or comorbidities. Since CMS has not developed or validated a specific risk adjustment model to account for patient comorbidities in the CJR model, hospitals treating sicker patients or those with a greater number of comorbidities may be penalized unfairly. Some readmissions are preventable and may be avoided if the cause of the readmissions are known, and care is provided at the right time during the hospital stay. Patients with joint replacement have multiple chronic conditions, and the success of the CJR model will depend upon identifying individual comorbid conditions and providing efficient patient-centered care that manages risk by aligning post-acute services to reduce readmissions. Understanding the effect of individual comorbid conditions included in each comorbidity index on hospital readmission may assist the process of discharge planning.

Comorbidity indices are widely used in risk adjustment models to predict mortality and health care utilization [7–9]. Commonly used indices are the Charlson Comorbidity Index

(Charlson), the Elixhauser Comorbidity Index (Elixhauser); and, more recently, the CMS risk adjustment model - Hierarchical Condition Category (HCC). The Charlson was developed to predict one-year all-cause mortality in patients with breast cancer using hospital medical records [7]. The Elixhauser was developed to predict in-hospital mortality, length of stay, and hospital charges [8]. Both the Charlson and Elixhauser have been used extensively in health service studies to examine acute and post-acute outcomes and readmissions [10–12]. The Hierarchical Condition Category (HCC) was developed by the CMS using demographic characteristics and medical comorbidities to estimate annual expenditures for beneficiaries enrolled in Medicare Advantage plans [9]. The CMS currently uses the HCC to develop risk-adjustment scores for individual patients based on an algorithm that includes combinations of diagnoses, patient age, and comorbidities included in the HCC [9]. Recently, the CMS included the HCC in a risk prediction model of 30-day unplanned hospital readmission [13].

The purpose of this study was to compare the performances of the Charlson, Elixhauser, and HCC in predicting post-acute discharge settings and 30-, 60-, and 90-day unplanned hospital readmission in patients after joint replacements related to OA. This study retrieved inpatient data using Medicare files associated with acute hospitalization to identify comorbidities associated with readmission during a 90-day episode of care. Understanding the effect of comorbidities on discharge settings and hospital readmission during a 90-day episode of care will provide acute hospitals with information to better estimate the risks during the transition between acute and post-acute care services and settings.

MATERIAL AND METHODS

Study design, data source, and patient population

This study was a secondary analysis of claims data for Medicare beneficiaries with total hip or total knee replacements discharged from acute hospitals between January 1, 2009, and September 30, 2011. The study used the Medicare Beneficiary Summary files and the Medicare Provider Analysis and Review (MedPAR) files associated with acute hospitals. Total hip and total knee replacement cases were identified using the Medicare Severity-Diagnosis Related Group (MS-DRG) codes 469 and 470, respectively, which are covered in the CJR model.

A visual representation of the selection process used to obtain the final sample is provided in Figure 1. The eligible study population consisted of 754,499 patients enrolled in the Medicare fee-for-service program, aged 66 years or older, discharged from an acute hospital to one of three post-acute settings [inpatient rehabilitation facility (IRF), skilled nursing facility (SNF), or home health (HH)] who survived 90 days from the index acute hospitalization discharge. We excluded patients undergoing joint replacements for reasons other than OA. This included persons with lower extremity fractures (n=123,290), with rheumatoid arthritis (n=2,273), and other causes (n=21,587). We also excluded patients with partial hip replacements (n=570) and other joint-related surgical procedures, not classified as total replacements (n=1,362). The final sample included 605,417 patients who received elective total hip or knee replacements (THR or TKR) due to underlying OA and represented

(80%) of the original sample. This study was approved by the University Institutional Review Board and a data use agreement (DUA) was established with CMS.

Demographic information, including age, gender, race/ethnicity, disability (the original reason for Medicare enrollment), and dual eligibility (enrolled in both Medicare and Medicaid) were extracted from the beneficiary summary file. Additional covariates included were hospital length of stay, intensive care unit (ICU) stay, number of acute hospitalizations in the prior year, and the CMS-proposed Hospital Acquired Conditions (HAC) such as Catheter-Associated Urinary Tract Infection (CAUTI) and Deep Vein Thrombosis and Pulmonary Embolism (DVTPE).

Outcome measures

Study outcomes included post-acute discharge settings: IRF, SNF, and HH and 30-, 60-, and 90-day unplanned hospital readmission. The post-acute discharge settings were determined using the “discharge destination” variable from the MedPAR, which was matched with the subsequent claim information associated with IRF and SNF stay in the MedPAR files. For HH, we used the “home health” category from the discharge destination variable due to the non-availability of HH claims data for the study period. The readmission measure used in the study was retrieved from the MedPAR claim and dichotomized into yes or no categories for 30-, 60-, and 90-days.

Comorbidity Indices

The Charlson consists of 18 medical conditions [14]. The sum of the weighted score for the 18 conditions was developed for each patient. The Elixhauser consists of 30 medical conditions. Walraven and colleagues developed weights for the Elixhauser for predicting hospital mortality [15]. We computed the Elixhauser composite score using these weights [15]. The CMS-HCC scores are calculated for Medicare Advantage enrollees from the ambulatory and inpatient claims [9]. For this study, we used the V1213.70.J1 version of the HCC. The specific comorbid conditions included in all three comorbid indices were identified using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnostic codes associated with the claims data. Dichotomous indicators (yes/no) were used for each condition included in the Charlson, Elixhauser, and HCC. We used composite comorbidity scores, as well as individual comorbid conditions to test their association with the study outcomes. Furthermore, we also examined the independent effects of most frequent comorbid conditions from each of the comorbidity indices on 30-, 60-, 90-day readmission.

Statistical Analyses

Descriptive statistics for sociodemographic and clinical characteristics were stratified by location of joint replacement (hip and knee). Chi square tests were used for categorical variables and *t* tests for continuous variables to examine the distribution by joint replacement location. Multinomial logistic regression models were used to examine the discriminative ability of the three comorbidity indices to predict post-acute discharge settings using HH as a reference category. Logistic regression models were computed to examine the discriminative ability of the three comorbidity indices to predict 30-, 60-, and 90-day

hospital readmission. The base model included age, gender, race, disability based on initial Medicare claim, Medicare-Medicaid dual eligibility, length of stay, ICU use, number of acute hospitalizations in the prior year, and the CAUTI and DVTPE. Subsequent models included one of the three comorbidity indices. Post-acute discharge settings were added to the base model when predicting hospital readmission. The *C*-statistics were compared to examine the discriminatory ability of the three comorbidity indices. The *C*-statistic indicates the probability that a randomly selected subject who experienced the outcome of interest (30-, 60-, 90-day readmission or discharge destination) has a higher predicted probability compared to a randomly selected subject who did not experience the outcome of interest [16]. Potential *C*-statistic values range from 0.5, meaning the model does no better than chance, to 1.0, meaning perfect discrimination [17]. A *C*-statistic higher than 0.70 is considered clinically relevant [17]. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

Table 1 compared the demographic and clinical characteristics of the study sample, by the location of joint replacement (hip and knee). The percentages in Table 1 were calculated according to the total sample. Overall, HH was the most prevalent post-acute discharge setting (46.3%), followed by SNF (40.9%), and IRF (12.7%). Patients with TKR demonstrated higher discharge to HH (47.4% versus 43.6%) compared to patients with THR. The unadjusted unplanned readmission rates were higher in patients with TKR than in patients with THR during the episode of care (30-, 60-, 90-day).

The *C*-statistics for each model predicting post-acute discharge settings and unplanned hospital readmission are presented in Table 2. The *C*-statistics in the base model for predicting post-acute discharge settings in patients with TKR and THR were 0.66 and 0.67, respectively. For post-acute discharge destination, when the weighted comorbidity indices score was added to the base model, the *C*-statistics did not increase substantially. Similarly, when the individual comorbidity conditions from each of the indices were added to the base model, the *C*-statistic did not increase substantially. For 30-, 60-, and 90-day unplanned hospital readmission, the *C*-statistics did not increase substantially after adding weighted comorbidity index scores or individual comorbidity conditions. Tables 3 and 4 report the top five prevalent conditions from each of the comorbidity indices in TKR and THR, respectively.

DISCUSSION

We compared the discriminatory ability of three comorbidity indices to predict post-acute discharge settings and 30-, 60-, and 90-day unplanned hospital readmissions in a national sample of Medicare beneficiaries discharged from the hospital following lower extremity joint replacement. Our results suggest that none of the comorbidity indices performed significantly better than the base model in predicting post-acute discharge settings or unplanned hospital readmissions (*C*-statistics < 0.70). The base model contributed the majority of the discrimination for predicting post-acute discharge settings and risk of hospital readmission. These results are consistent with findings from previous studies

showing the limitation of comorbidity indices in predicting discharge functional status and readmission after discharge from an acute hospital stay [11, 12].

While the CMS-HCC score might be correlated with the cost of services for the episode of care [18], the current HCC scoring algorithm does not appear to be sensitive to discharge destination or readmission in the continuum of post-acute care. Similarly, Charlson was developed to predict mortality, and conditions included in Charlson are sensitive to that outcome. The weighted comorbidity scores for all three comorbidity indices are widely used in health services research for risk adjustment to examine outcomes they were not developed to predict [12, 19].

The findings from this and other studies indicate that commonly used comorbidity indices included in the CMS risk adjustment model do not accurately predict functional status, discharge destinations or the risk of hospital readmission [11, 20, 21]. These findings suggest directions for future research. One is the identification of other measures, such as obesity or functional status, that can accurately predict discharge setting and hospital readmission [19, 22]. Previous research has shown that functional status has improved discriminatory ability over comorbidity indices to predict 30-day hospital readmission and discharge to the community in Medicare beneficiaries [20, 21, 23, 24]. However, the majority of the current risk-adjustment models, including those developed by CMS for readmission, do not include functional status and obesity [13, 23]. Given that patient undergoing joint replacement have mobility limitations, pain, and obesity [25], it may be logical to include discharge functional status in the acute care setting in the current risk adjustment model to better coordinate post-discharge care. Unlike post-acute care settings (e.g., Functional Independence Measure in IRF and Minimum Data Set in SNF), acute hospitals currently do not collect or report uniform and standardized patient-level functional status information to the CMS.

Our results have important implications as none of the comorbidity indices and CMS risk adjustment model-HCC substantially improved the base model's ability to predict hospital readmission. Identifying individual conditions within these indices may be informative to clinicians in identifying patients with OA at "high risk" for hospital readmission or other unintended health outcomes. The results suggest that instead of emphasizing composite comorbidity index scores, which can mask the individual effects of a comorbid condition, identifying individual medical conditions could be a more appropriate approach to predict quality indicators, such as hospital readmission. In patients with TKR and THR, readmission can be prevented by the management of common medical conditions or risk factors identified in this study such as diabetes, hypertension, heart disease, and chronic lung disease.

Implementation of the CJR program, which started on April 1, 2016, highlights the importance of risk adjustment for predicting health outcomes throughout the episode of care [6]. Although the CJR initiative is intended to eliminate the silos model in which existing health services delivery and reimbursement of these services operate, its effectiveness hinges on the assessment and management of patient medical severity. Our study supports the

development and standardization of a uniform risk adjustment method to assess the entire episode of care for patients with joint replacements.

Our study has limitations that need to be acknowledged. First, we use the weighted score for all three comorbidity indices; those weights, developed for mortality, may not be adequately sensitive to our study outcomes. Previous studies have used weighted scores for Charlson and Elixhauser to investigate outcomes other than mortality and health services utilization [12]. Also, we restricted our sample selection to those with elective joint replacements due to underlying OA and outcomes may not be generalizable to patients with other underlying rheumatic conditions (e.g., rheumatoid arthritis) or fractures resulting in joint replacements. It is worth noting that the CJR model is based on the Diagnosis Related Groups codes 469 and 470, which in itself does not capture patient-level case severity [6]. However, our study identifies the need to adjust for specific medical conditions, which could have an impact on the episode of care. Finally, we included only patients enrolled in the fee-for-service plan, and our results may not apply to patients enrolled in Medicare Advantage or other Health Maintenance Organization plans.

In summary, our results suggest that the comorbidity indices (Charlson, and Elixhauser), and CMS risk adjustment model HCC demonstrated weak associations with post-acute discharge settings and hospital readmission in patients with hip or knee joint replacements. Further research is recommended to develop and calibrate outcome-specific weighted composite or co-occurring multiple chronic conditions for predicting patient-centered outcomes throughout the episode of care. With the implementation of CJR, better assessment of patient-level risk factors is needed to manage high-risk patients with multiple chronic conditions as the continuum of care continues to expand.

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Significance and Innovations

This study evaluated comorbidity indices and CMS risk adjustment model (HCC) for predicting health services outcomes during a 90-day episode of care for patients with total knee or hip replacement.

- Individual comorbid conditions were stronger predictors of hospital readmission than composite score during a 90-day episode of care for patients with joint replacement. The information on individual comorbid conditions will be useful for health care providers to initiate preventive steps to avoid adverse outcomes (readmission) and higher health care utilization.
- Understanding the impact of comorbidities on hospital readmission has implications for developing robust risk adjustment methodology for bundled payment specific to joint replacement.
- In the absence of a sensitive risk adjustment model, hospitals treating a large number of patients with joint replacements with multiple comorbidities could perform worse on public reporting quality measures, such as hospital readmission.
- Providers may improve service delivery by developing appropriate care transition plans for specific comorbid conditions associated with greater risk of readmission.

Figure 1.
Selection of study cohorts

Table 1

Descriptive characteristics of the study sample by the location of joint replacement.

Variable	Total Sample	Total Hip Replacement	Total Knee Replacement	<i>p</i> value *
	605,413	183,578 (30.3)	421,835 (69.6)	
Age (mean ± SD)	75.0 ± 6.2	75.6 ± 6.4	74.7 ± 6.0	<.0001
66 – 75	337361 (55.7)	95469 (52.0)	241892 (57.3)	
76 – 85	231015 (38.1)	73325 (39.9)	157690 (37.4)	<.0001
>85	37037 (6.1)	14784 (8.1)	22253 (5.3)	
Female	396530 (65.5)	116565 (63.5)	279965 (66.4)	<.0001
Male	208883 (34.5)	67013 (36.5)	141870 (33.6)	
Race/Ethnicity				
White	539780 (89.1)	169212 (92.2)	370568 (87.8)	
Black	33136 (5.4)	8691 (4.7)	24445 (5.8)	<.0001
Hispanic	21558 (3.5)	3487 (1.9)	18071 (4.7)	
Other	10939 (1.8)	2188 (1.2)	8751 (2.1)	
Dual Eligibility	54287 (8.9)	13252 (7.2)	41035 (9.7)	<.0001
Disability	48291 (7.9)	12671 (6.9)	35620 (8.4)	<.0001
ICU Use	27588 (4.5)	9467 (5.2)	18121 (4.3)	<.0001
Length of Stay (mean ± SD)	3.4 ± 1.4	3.4 ± 1.5	3.4 ± 1.4	<.0001
Hospital Acquired Conditions				
CAUTI	19668 (3.2)	6391 (3.5)	13277 (3.1)	<.0001
DVTPE	4544 (0.7)	689 (0.4)	3855(0.9)	<.0001
Number of Acute Hospitalization in the Prior Year				
0	505781 (83.5)	150968 (82.2)	354813 (84.1)	
1	77477 (12.8)	24815 (13.5)	52662 (12.5)	
2	15838 (2.6)	5462 (3.0)	10376 (2.5)	<.0001
3+	6317 (1.0)	2333 (1.3)	3984 (0.9)	
Comorbidity Indices Weighted Composite Score (mean ± SD)				
Charlson	4.3 ± 0.9	4.4 ± 0.9	4.3 ± 0.9	<.0001
Elixhauser	1.4 ± 4.0	1.6 ± 4.0	1.4 ± 4.0	<.042
HCC	1.2 ± 0.3	1.3 ± 0.3	1.2 ± 0.3	<.0001
Post-acute Discharge Destination				
HHA	280342 (46.3)	80035 (43.6)	200307 (47.4)	
IRF	77327 (12.7)	25785 (14.0)	51542 (12.2)	<.0001
SNF	247744 (40.9)	77758 (42.3)	169986 (40.3)	
Unplanned Hospital Readmission				
30-Day Readmission	32376 (5.3)	10232 (5.6)	22144 (5.2)	<.0001
60-Day Readmission	44072 (7.2)	13875 (7.6)	30197 (7.2)	<.0001
90-Day Readmission	51689 (8.5)	16263 (8.9)	35426 (8.4)	<.0001

Values are presented as mean ± standard deviation (SD) or N (%).

* Chi-square tests for categorical variables and ANOVA for continuous variables. Percent of each categorical variable given in the column is from total of THR and TKR group. *P*-values compared the distribution of the independent and outcome variables between the total hip and total knee replacement. HH: Home Health, IRF: Inpatient Rehabilitation Facilities, SNF: Skilled Nursing Facility, ICU: Intensive Care Unit, CAUTI: Catheter-Associated Urinary Tract Infection, DVTPE: Deep Vein Thrombosis and Pulmonary Embolism, HCC: Hierarchical Condition Category.

Length of stay is based on number of days (mean $\pm$ SD was reported)

Percentages for the total sample are presented as column percentages. Percentages for total hip replacement and total knee replacement were calculated according to the total sample.

Table 2

Comparison of *C*-statistics for predicting discharge destination and hospital readmissions stratified by location of replacement.

Model	Discharge IRF/SNF* <i>C</i> -Statistics	30-Day Readmission <i>C</i> -Statistics	60-Day Readmission <i>C</i> -Statistics	90-Day Readmission <i>C</i> -Statistics
Total Knee Replacement				
Base Model	0.660	0.635	0.643	0.649
Weighted Charlson Score	0.667	0.639	0.647	0.652
Weighted Elixhauser Score	0.665	0.640	0.648	0.653
Weighted HCC Score	0.667	0.648	0.656	0.661
Indices including individual comorbid conditions				
Charlson	0.668	0.641	0.649	0.654
Elixhauser	0.673	0.649	0.657	0.662
HCC	0.671	0.651	0.660	0.664
Total Hip Replacement				
Base Model	0.670	0.638	0.647	0.650
Weighted Charlson Score	0.681	0.640	0.650	0.654
Weighted Elixhauser Score	0.679	0.640	0.650	0.653
Weighted HCC Score	0.681	0.648	0.659	0.662
Indices including individual comorbid conditions				
Charlson	0.682	0.642	0.652	0.656
Elixhauser	0.685	0.650	0.659	0.663
HCC	0.684	0.650	0.660	0.664

Base model included age, gender, race, disability, dual eligibility, length of stay, intensive care unit use, number of acute hospitalizations in the prior year, catheter-associated urinary tract infection, deep vein thrombosis and pulmonary embolism, and discharge destination (only included in the model for predicting readmission).

IRF: inpatient rehabilitation facility, SNF: skilled nursing facility, HCC: Hierarchical Condition Category.

* Discharge to IRF and SNF was compared to reference group Home Health.

Table 3

The top five comorbid conditions in each of the comorbidity indices and their association with readmission in patients with total knee replacement.

Comorbid Conditions	N (%)	30-day OR (95% CI)	60-day OR (95% CI)	90-day OR (95% CI)
Charlson				
Diabetes without Complication	86207 (20.4)	1.14 (1.10 – 1.18)	1.15 (1.11 – 1.18)	1.16 (1.12 – 1.18)
Chronic Pulmonary Disease	24364 (5.7)	1.37 (1.31 – 1.44)	1.35 (1.29 – 1.41)	1.35 (1.29 – 1.40)
Myocardial Infarction	15106 (3.5)	1.25 (1.17 – 1.34)	1.25 (1.18 – 1.33)	1.26 (1.19 – 1.32)
Peripheral Vascular Disease	14635 (3.4)	1.20 (1.10 – 1.32)	1.21 (1.12 – 1.31)	1.23 (1.14 – 1.32)
Diabetes with Complication	5237 (1.2)	1.47 (1.33 – 1.63)	1.52 (1.39 – 1.66)	1.51 (1.39 – 1.63)
Elixhauser				
Hypertension	111292 (26.4)	1.06 (1.03 – 1.10)	1.05 (1.02 – 1.08)	1.04 (1.01 – 1.07)
Diabetes without Chronic Complication	89180 (21.1)	1.14 (1.10 – 1.18)	1.15 (1.12 – 1.19)	1.16 (1.13 – 1.19)
Hypothyroidism	73,420 (17.4)	1.00 (0.96 – 1.04)	1.00 (0.97 – 1.03)	1.00 (0.97 – 1.03)
Anemia Deficiency	59,300 (14.1)	1.04 (1.00 – 1.08)	1.03 (1.00 – 1.06)	1.03 (0.99 – 1.06)
Chronic Lung Disease	57275 (13.6)	1.29 (1.24 – 1.33)	1.30 (1.25 – 1.33)	1.29 (1.25 – 1.32)
HCC				
Diabetes without Complication	90004 (21.3)	1.14 (1.11 – 1.18)	1.19 (1.12 – 1.19)	1.16 (1.13 – 1.20)
Specified Heart Arrhythmias	39290 (9.3)	1.29 (1.23 – 1.34)	1.33 (1.28 – 1.37)	1.33 (1.29 – 1.37)
Chronic Obstructive Pulmonary Disease	31513 (7.50)	1.36 (1.30 – 1.43)	1.36 (1.31 – 1.42)	1.37 (1.32 – 1.42)
Renal Failure	27554 (6.5)	1.38 (1.31 – 1.44)	1.39 (1.33 – 1.44)	1.38 (1.32 – 1.43)
Congestive Heart Failure	19251 (4.6)	1.31 (1.24 – 1.38)	1.36 (1.30 – 1.43)	1.39 (1.33 – 1.45)

The OR were adjusted for patient characteristics (age, gender, race, disability, dual eligibility, length of stay, intensive care unit use, number of acute hospitalizations in the prior year and discharge destination). CAUTI: catheter-associated urinary tract infection, DVTPE: deep vein thrombosis and pulmonary embolism, OR: odds ratio, CI: confidence interval, Charlson: Charlson Comorbidity Index, Elixhauser: Elixhauser Comorbidity Index, HCC: Hierarchical Condition Category.

Table 4

The top five comorbid conditions in each of the comorbidity indices and their association with readmission in patients with total hip replacement.

Comorbid Conditions	N (%)	30-day OR (95% CI)	60-day OR (95% CI)	90-day OR (95% CI)
Charlson				
Diabetes without Complication	27699 (15.1)	1.12 (1.06 – 1.19)	1.14 (1.09 – 1.19)	1.15 (1.10 – 1.19)
Chronic Pulmonary Disease	12678 (6.9)	1.28 (1.19 – 1.37)	1.36 (1.28 – 1.44)	1.37 (1.29 – 1.45)
Myocardial Infarction	6913 (3.7)	1.13 (1.03 – 1.25)	1.15 (1.06 – 1.25)	1.14 (1.05 – 1.23)
Peripheral Vascular Disease	3476 (1.9)	1.14 (1.00 – 1.30)	1.15 (1.03 – 1.29)	1.15 (1.03 – 1.28)
Diabetes with Complication	1607 (0.9)	1.21 (1.01 – 1.46)	1.27 (1.08 – 1.49)	1.31 (1.13 – 1.52)
Elixhauser				
Hypertension	56915 (31.0)	1.08 (1.03 – 1.13)	1.07 (1.02 – 1.11)	1.08 (1.03 – 1.11)
Hypothyroidism	29669 (16.2)	0.98 (0.92 – 1.03)	0.99 (0.94 – 1.04)	1.00 (0.96 – 1.05)
Diabetes without chronic complication	28526 (15.5)	1.11 (1.05 – 1.17)	1.12 (1.07 – 1.18)	1.13 (1.08 – 1.18)
Anemia Deficiency	27866 (15.2)	1.05 (0.99 – 1.11)	1.06 (1.01 – 1.11)	1.05 (1.01 – 1.10)
Chronic Lung Disease	25310 (13.7)	1.28 (1.22 – 1.35)	1.32 (1.26 – 1.38)	1.34 (1.28 – 1.40)
HCC				
Diabetes without Complication	28746 (15.7)	1.12 (1.07 – 1.19)	1.14 (1.09 – 1.19)	1.15 (1.00 – 1.19)
Specified Heart Arrhythmias	18101 (9.9)	1.30 (1.23 – 1.38)	1.28 (1.21 – 1.35)	1.28 (1.22 – 1.35)
Chronic Obstructive Pulmonary Disease	16178 (8.8)	1.34 (1.26 – 1.42)	1.41 (1.34 – 1.49)	1.42 (1.35 – 1.50)
Renal Failure	12079 (6.6)	1.40 (1.30 – 1.49)	1.39 (1.31 – 1.48)	1.38 (1.31 – 1.46)
Congestive Heart Failure	8618 (4.7)	1.14 (1.06 – 1.24)	1.20 (1.12 – 1.28)	1.25 (1.17 – 1.33)

The OR were adjusted for patient characteristics (age, gender, race, disability, dual eligibility, length of stay, intensive care unit use, number of acute hospitalizations in the prior year and discharge destination). DVTPE: deep vein thrombosis and pulmonary embolism, OR: odds ratio, CI: confidence interval, HCC: Hierarchical Condition Category.