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Potentially Preventable Readmissions Claims-Based Measure for Home Health: Risk Adjustment Methodology

December 2016

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1 INTRODUCTION

The Improving Medicare Post-Acute Care Transformation Act of 2014 (IMPACT Act), enacted on October 6, 2014, requires the development and standardization of the *Potentially Preventable Readmissions* (PPR) measure across four post-acute care (PAC) settings: home health agencies (HHAs), skilled nursing facilities (SNFs), long-term care hospitals (LTCHs), and inpatient rehabilitation facilities (IRFs). The *Potentially Preventable Readmissions* measure for HHAs estimates the risk-standardized rate of unplanned, potentially preventable readmissions for patients (Medicare Fee-for-Service [FFS] beneficiaries) in the 30-days following a home health (HH) discharge.

This report summarizes the statistical risk model, variable specifications, the variable selection process, and the performance of the risk adjustment model for the claims-based *Potentially Preventable Readmissions* measure calculated for the home health Medicare FFS population. Section 2 describes the statistical risk model. Then Section 3 details the set of potential risk factors and each variable's specifications. Next, Section 4 describes how a subset of these risk factors was selected for the final predictive model. Section 5 evaluates the risk adjustment model's performance and appropriateness for this measure. Finally, Appendix A provides the risk adjustment model results.

2 STATISTICAL RISK MODEL

In alignment with the IRF, LTCH, and SNF PPR measures, we used a hierarchical logistic regression method to predict the probability of a PPR. Patient characteristics related to PPRs and a marker for the specific discharging facility are included in the equation. We utilized a hierarchical model in order to account for both individual patient characteristics as well as the clustering of patient characteristics within HHAs. The statistical model estimates both the average predictive effect of the patient characteristics across all HHAs, and the degree to which each HHA has an effect on PPR risk that differs from that of the average HHA. The HHA effects are assumed to be randomly distributed around the average (according to a normal distribution). When computing the HHA effect, hierarchical modeling accounts for the known predictors of a PPR, on average, such as patient characteristics, the observed HHA rate, and the number of HHA stays eligible for inclusion in the measure. The estimated HHA effect is determined mostly by the HHA's own data if the number of eligible stays is relatively large (as the estimate would be relatively precise), but is adjusted toward the average if the number of eligible stays is small (as that would yield a less precise estimate).

We used the following model:

Let Y_{ij}, denote the outcome (equal to 1 if patient *i* has a PPR, 0 otherwise) for a patient *i* at facility *j*; Z_{ij} denotes a set of risk adjustment variables. We assume the outcome is related to the risk adjusters via a logit function with dispersion:

$$logit\left(Prob(Y_{ij})\right) = \alpha_j + \beta \times Z_{ij} + \varepsilon_{ij}$$

$$\alpha_j = \mu + \omega_j; \omega_j \sim N(0, \tau^2)$$

where $Z_{ij} = (Z_1, Z_2, \ldots Z_k)$ is a set of *k* patient-level risk adjustment variables; alpha sub *j* represents the HHA-specific intercept; mu is the adjusted average outcome across all facilities; tau squared is the between-HHA variance component; and epsilon approximately equal to the N of sigma squared at zero is the error term. The hierarchical logistic regression model is estimated using SAS software (PROC GLIMMIX: SAS/STAT User's Guide, SAS Institute Inc.).

The estimated equation is used twice in the measure. The sum of the probabilities of PPR of all patients in the HHA measure, including both the effects of patient characteristics and the HHA, is the "predicted number" of PPRs after adjusting for the HHA's case mix. The same equation is used without the HHA effect to compute the "expected number" of PPRs for the same patients at the average HHA. The ratio of the predicted-to-expected number of PPRs is a measure of the degree to which PPRs are higher or lower than what would otherwise be expected. This standardized risk ratio is then multiplied by the mean PPR rate for all HHA stays for the measure, yielding the risk-standardized PPR rate for each HHA.

3 VARIABLE SPECIFICATION

To account for beneficiary characteristics that may affect the risk of PPR, the risk adjustment model uses potential risk factors that fall into three categories:

(1) Demographics;

(2) Care received during the prior proximal hospitalization; and

(3) Other care received within one year of the HH stay.

The following sub-sections detail risk factors in each of these categories in turn.

3.1 Factor 1: Demographics

Demographic risk factors included in the risk adjustment model are age and sex, enrollment status, and activities of daily living (ADL) scores.

3.1.1 Age and Sex

The risk adjustment model includes age and sex as covariates. Age-sex interactions allow the model to account for the differing effects of age on the outcomes for each sex. Age is subdivided into 12 bins for each sex: ages 18-34, 35-44, 45-54, five-year age bins from 55 to 95, and one bin for ages over 95. 65-69, Male is the reference group.

3.1.2 Enrollment Status

The model employs aged (reference), end stage renal disease (ESRD), and disability as covariates for the original reason for Medicare entitlement.

3.1.3 Activities of Daily Living Scores

The Home Health Prospective Payment System (HH-PPS) calculates an Activity of Daily Living (ADL) Severity Score by combining responses from several Outcome and Assessment Information Set (OASIS) fields. The ADL Severity Score is calculated using four methods that differ by how much weight is assigned to the OASIS variables that comprise the score. These four scores are then combined with information related to episode timing (early/late status) and the number of therapy visits to determine which Severity Score is placed on the five-character Health Insurance Prospective Payment System (HIPPS) code as the ADL Severity Score. The risk adjustment model includes all four Severity Scores (i.e., ADL 1-4).

3.2 Factor 2: Care Received during the Prior Proximal Hospitalization

Because beneficiaries who enter home health care from prior proximal hospitalizations[1] may have different health statuses, this model takes into account beneficiaries' immediate prior care setting, principal diagnoses, and procedures.

3.2.1 Length of Prior Proximal Hospitalization

The length of the prior proximal hospitalization is included in the model as a binary variable: 1-7 days (reference) and greater than or equal to 8 days.

3.2.2 Clinical Classification Software (CCS) during Prior Proximal Hospitalization

The risk model relies on CCS diagnosis and procedure groups to adjust for beneficiary health status during the prior proximal hospitalization. CCS diagnosis groups are defined using principal diagnosis codes from the prior proximal hospitalization. CCS procedure groups are defined using procedure codes recorded during the prior proximal hospitalization.

3.3 Factor 3: Other Care Received within One Year of Stay

To further account for beneficiaries who may have different health statuses entering into home health, this model adjusts for the beneficiaries' number of prior acute discharges, number of emergency department visits, and Hierarchical Condition Categories (HCC) comorbidities.

3.3.1 Number of Prior Acute Discharges

The model adjusts for the number of prior acute[2] discharges (excluding the prior proximal hospitalization) within one year of the HH stay. The number of prior acute discharges is classified in the model as 0 (i.e., no prior acute discharge; reference group), 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 or more discharges.

3.3.2 Number of Outpatient Emergency Department Visits

The model also takes into account whether or not an outpatient emergency department (ED) visit took place within one year of the HH stay (i.e., 0 ED visits [reference] or 1 or more ED visits).

[1] Prior proximal hospitalizations for the PPR measure are defined as a short-term acute-care or psychiatric stay within 30 days prior to home health admission. Prior proximal hospitalizations are indicated by the discharge date from an inpatient claim for an acute care hospital (CMS Certification Numbers [CCN] ending in 0001-0879, 0880-0899, and 1300-1399) or psychiatric facility (CCNs ending in 4000-4499).
[2] Acute care hospitals are defined as CCNs ending in 0001-0879, 0880-0899, and 1300-1399.

3.3.3 Hierarchical Condition Categories (HCC) Comorbidities

To account for beneficiary health status within one year of the HH stay, the risk adjustment model also relies on the HCC framework[3]. The risk adjustment model includes 38 hierarchically ranked HCCs based on the 2009 CMS-HCC risk adjustment model. HCC comorbidities are defined using secondary diagnoses from the prior proximal hospitalization and all other diagnoses recorded in the inpatient, outpatient, and carrier settings during the year prior to the home health stay.

[3] CMS-HCC Mappings of ICD-9 Codes: Mappings are included in the software at the following website: http://www.cms.gov/Medicare/Health-Plans/MedicareAdvtgSpecRateStats/Risk-Adjustors.html

4 VARIABLE SELECTION

Several steps were implemented to develop a model that accounts for important risk factors while also ensuring that the model is not over fit to the data. The Least Absolute Shrinkage and Selection Operator (LASSO) was one of the analyses used to guide the variable selection process. The LASSO technique is designed to develop models that minimize prediction error in a manner that does not overfit the data. The nature of the LASSO function encourages parameter estimates of unimportant predictors to shrink to zero (which effectively eliminates these variables from the model). Additionally, the LASSO technique utilizes cross-validation to establish the set of model predictors that consistently result in a relatively low prediction error. The remainder of this section describes why the LASSO method for variable selection is particularly useful in this context and outlines the measure selection process.

4.1 Use of LASSO for Model Selection

LASSO is particularly appropriate for the home health PPR measure because of the need to select a parsimonious set of predictors from a large number of available variables as well as the need for a risk model that performs consistently across data updates. A large number of independent variables were under consideration for this measure, including diagnosis and procedure code groupings, age-sex interactions and prior healthcare utilization, among others. While it is important to consider all of the available variables, it is also important to avoid overfitting the data. Because of sample-specific relationships, a model that minimizes prediction error in one sample may be too closely tailored and generate large prediction errors in another sample. Given that the PPR risk adjustment model will be applied to new data as the measure is updated annually, it is important that model performance remain consistent across data updates. Because LASSO utilizes cross-validation to evaluate prediction error, it lends itself well to generating models that perform consistently across datasets; thus, it is expected that the risk-adjustment model will perform consistently as data are updated annually.

4.2 Covariate Selection Methodology

Considering the volume of independent covariates available for this model, multiple steps were taken to eliminate variables that do not improve the model's predictive ability or that do not predict PPR risk in a consistent manner. All variable selection activities were performed using a training dataset comprised of an eighty percent random sample of the population of eligible home health stays. Covariate selection occurred in three stages:

(1) Before initiating the LASSO, we eliminated all independent variables that have fewer than 500 occurrences in our population across all three years of data. The population consisted of roughly 4 million home health stays, so this eliminated covariates appearing in approximately 0.01% of stays and which were unlikely to meaningfully improve

model performance. Furthermore, we eliminated all variables with zero PPRs in any individual year. As described below in #3, this exclusion was necessary to run annual logistic regression models assessing each covariate's stability over time. When zero PPRs were observed in a given year for a particular variable, it was observed that there were also zero or very low numbers of PPRs for the same variable in adjacent years.

(2) LASSO was implemented using the "glmnet" package in R to select which of the remaining variables were important to include in the risk model.

(3) Lastly, after the LASSO provided a list of suitable model covariates, we checked to ensure that each covariate's predictive ability is consistent across calendar years (because the final model will be applied to annually updated data). To test this, we constructed logistic regression models controlling for the list of variables provided by LASSO, stratified by calendar year. If the point estimates for a particular variable were not consistently above or below the null across calendar years, then that variable was eliminated from the final model.

5 MODEL PERFORMANCE

This section evaluates the risk adjustment model and illustrates its appropriateness for the PPR measure. First, Section 5.1 describes the analysis performed to confirm that the variables selected by LASSO were appropriate for the final hierarchical model. Section 5.2 examines how risk adjustment affects the distribution of PPR rates overall. Finally, Section 5.3 evaluates the model fit in both the training and validation datasets. The final population comprised of 4,094,261 home health stays attributed to 12,062 HHAs. The detailed model results are included in Appendix A.

5.1 Comparison of Parameter Estimates between the LASSO and Random Effects Models

The LASSO model used for variable selection does not account for the clustering of eligible stays within HHAs. The final hierarchical risk adjustment model, on the other hand, does account for this clustering. Therefore, it was important to confirm that the variables selected using LASSO were also appropriate for the final risk model. To this end, we compared the parameter estimates of the covariates remaining in the risk model after implementing LASSO between two hierarchical logistic regression models: one that accounts for the clustering of stays and another that does not. We found the model coefficients were very close across these two models; therefore, we concluded that the variables selected using LASSO were also appropriate for the final hierarchical risk model.

5.2 Distributions of Observed Rates and Risk Standardized Readmission Rates (RSRRs)

The unadjusted readmission rates range from 0.0 to 34.5 percent, with a median of 3.6 percent and an interquartile range of 2.5 to 5.1 percent. The RSRR, compared to the observed unadjusted rate, had a narrower range, from 2.1 to 9.6 percent, with a slightly higher median of 3.8 percent and a tighter interquartile range of 3.6 to 4.0 percent. The mean RSRR (3.8%) was slightly lower than the unadjusted rate (4.1%) and the scores had a much smaller standard deviation (0.5% vs. 2.8%). The compression of the RSRR distribution compared to the distribution of observed rates is expected because the hierarchical model adjusts each HHA toward the average performance rate. The extent to which an HHA is adjusted toward the average depends on the number of eligible stays included in the measure for the HHA. Table 5.1 presents the distributions of the observed rates and RSRRs of PPR for agencies with at least 20 home health stays using the full data set. Agencies with fewer than 20 eligible stays were excluded from this summary because they tend to have more extreme rates due to imprecision.

There was no evidence of a ceiling effect for this measure. The interquartile range shows that there was clustering in the middle of the distribution. This is in part attributable to the

shrinkage of RSRR scores towards the mean, though the risk adjustment itself can also compress the rate distribution.

Table 5.1: Distribution of Observed Rates and RSRRs for PPR among HHAs with at least 20 Eligible Stays

Rate	Mean	Std. Err	Min	10th percentile	25th percentile	Median	75th percentile	90th percentile	Max
Observed Rate	0.041	0.028	0.000	0.012	0.025	0.036	0.051	0.074	0.345
RSRR	0.038	0.005	0.021	0.033	0.036	0.038	0.040	0.044	0.096

5.3 Predictive Power

We evaluated the predictive power of the model for both the development sample and the validation sample. Evaluating model fit for the development sample shows how well the model predicts outcomes in the data on which it was developed, while evaluating model fit for the validation sample shows how well the model predicts outcomes outside the data on which it was developed. The area under the receiver operating curve (AUC) statistic, also known as the c-statistic, measures the ability of the model to differentiate between outcomes without resorting to an arbitrary cutoff point. A model that perfectly discriminates between outcomes would have a c-statistic of 1.0, while a model that has no predictive power would have a c-statistic of 0.5. The c-statistic for the development sample was 0.77, which suggests the risk model is well fit to the data in which it was developed. To assess the fit of model in the validation sample, the parameter estimates from the development sample were used to calculate the probability of an event for each home health stay in the validation sample. The c-statistic resulting from the validation dataset was 0.76, which is comparable to the c-statistic of 0.77 observed in the testing dataset. We also calculated the range of differences between the 10th and 90th percentile of RSRRs in both the training and validation datasets to further ensure the model will perform similarly as new data is added. In the development sample, the range of RSRRs was 3.4 percent to 4.2 percent and the range in the validation sample was 3.6 percent to 4.0 percent. The distribution of RSRRs fall within similar ranges, with the range in the validation being narrower than that of the validation dataset due to the relatively smaller number of eligible stays for each HHA in the validation sample. Overall, these results indicate that the model strongly fit the data and that the model continues to perform well (and consistently) when applied to new data.

6 CONCLUSION

This report describes the risk adjustment methodology and performance of the *Potentially Preventable Readmissions* measure of the home health population. A hierarchical, multivariate risk model was used to derive the HHA-level risk standardized readmission rates (RSRRs). The risk model employed the following sets of covariates:

(1) Demographics
   (a) Age and sex
   (b) Enrollment status
   (c) Activities of daily living scores
(2) Care received during the prior proximal hospitalization
   (a) Length of prior proximal hospitalization
   (b) Clinical classification software (CCS) diagnosis and procedure categories during the prior proximal hospitalization
(3) Other care received within one year of the HH stay
   (a) Number of prior acute discharges
   (b) Number of outpatient emergency department visits
   (c) Hierarchical condition categories (HCC) comorbidities

The specific set of 171 covariates used in the model consisted of demographic and healthcare utilization variables as well as clinical characteristics selected through a series of steps including the implementation of LASSO as well as analyses to ensure covariates consistently predict PPR risk over time. Implementing a hierarchical model adjusts for individual demographic and clinical characteristics, accounts for the clustering of stays within HHAs, compresses the distribution of PPR rates. Overall, the model strongly fits the data with a c-statistic of 0.77 and performs well (and consistently) when applied to new data.

APPENDIX A: RISK ADJUSTMENT MODEL RESULTS

Table A.1: Potentially Preventable Unplanned Readmission Measure for 30 Days Post Discharge Logistic Regression Model Results in 2011 - 2013

Variable Name in Model	Covariate	Count	Percent Total	Estimate	Std. Error	P value	Odds Ratio	OR 95% Lower CL	OR 95% Upper CL
Age-Sex Groups (Reference group: Male 65-69)									
age_18_34_f	18-34, Female	10,405	0.3	0.053	0.051	0.2873	1.05	1.04	1.27
age_18_34_m	18-34, Male	9,486	0.2	0.142	0.050	0.0054	1.15	0.96	1.16
age_35_44_f	35-44, Female	25,571	0.6	0.059	0.035	0.0819	1.06	1.05	1.21
age_35_44_m	35-44, Male	21,825	0.5	0.120	0.034	0.0007	1.13	0.99	1.13
age_45_54_f	45-54, Female	76,773	1.9	0.081	0.023	0.0003	1.08	1.01	1.10
age_45_54_m	45-54, Male	65,260	1.6	0.052	0.022	0.0272	1.05	1.04	1.13
age_55_59_f	55-59, Female	70,943	1.7	0.089	0.024	<.0001	1.09	1.02	1.12
age_55_59_m	55-59, Male	54,857	1.3	0.067	0.023	0.0063	1.07	1.05	1.14
age_60_64_f	60-64, Female	94,705	2.3	0.071	0.023	0.0006	1.07	1.00	1.09
age_60_64_m	60-64, Male	68,734	1.7	0.043	0.021	0.0575	1.04	1.03	1.12
age_65_69_f	65-69, Female	301,939	7.4	0.042	0.017	0.0128	1.04	1.01	1.08
age_65_69_m	65-69, Male (Reference)	210,974	5.2	-	-	-	-	-	-
age_70_74_f	70-74, Female	391,445	9.6	0.044	0.017	0.0063	1.04	1.04	1.11
age_70_74_m	70-74, Male	268,310	6.6	0.069	0.016	<.0001	1.07	1.01	1.08
age_75_79_f	75-79, Female	427,208	10.4	0.073	0.017	<.0001	1.08	1.03	1.10
age_75_79_m	75-79, Male	278,047	6.8	0.065	0.016	0.0001	1.07	1.04	1.11
age_80_84_f	80-84, Female	458,312	11.2	0.074	0.016	<.0001	1.08	1.08	1.15
age_80_84_m	80-84, Male	277,485	6.8	0.110	0.016	<.0001	1.12	1.04	1.11
age_85_89_f	85-89, Female	396,670	9.7	0.125	0.017	<.0001	1.13	1.13	1.21
age_85_89_m	85-89, Male	210,008	5.1	0.160	0.016	<.0001	1.17	1.10	1.17
age_90_94_f	90-94, Female	204,257	5.0	0.166	0.021	<.0001	1.18	1.22	1.32
age_90_94_m	90-94, Male	91,989	2.2	0.237	0.018	<.0001	1.27	1.14	1.22
age_95_pl_f	95+, Female	58,985	1.4	0.263	0.035	<.0001	1.30	1.24	1.43
age_95_pl_m	95+, Male	20,073	0.5	0.286	0.024	<.0001	1.33	1.24	1.36
Original Reason for Medicare Enrollment (Reference group: Age)									
orig_aged	Age (Reference)	3,121,093	76.2	-	-	-	-	-	-
orig_disabled	Disability	933,769	22.8	0.134	0.008	<.0001	1.14	1.12	1.16
orig_esrd	ESRD	39,399	1.0	0.190	0.023	<.0001	1.21	1.16	1.27

Variable Name in Model	Covariate	Count	Percent Total	Estimate	Std. Error	P value	Odds Ratio	OR 95% Lower CL	OR 95% Upper CL
Activities of Daily Living Score (Continuous, standardized variables)									
adl_1	ADL Score 1	4,094,261	100	-0.011	0.026	0.6675	0.99	0.94	1.04
adl_2	ADL Score 2	4,094,261	100	0.156	0.011	<.0001	1.17	1.14	1.19
adl_3	ADL Score 3	4,094,261	100	-0.058	0.026	0.0233	0.94	0.90	0.99
adl_4	ADL Score 4	4,094,261	100	0.019	0.011	0.0795	1.02	1.00	1.04
Length of Prior Proximal Hospitalization (Reference group: 1-7 Days)									
-	1-7 Days (Reference)	3,070,010	75.0	-	-	-	-	-	-
prior_proximal_8	≥ 8 Days	1,024,251	25.0	0.138	0.006	<.0001	1.15	1.13	1.16
Number of Prior Acute Discharges within One Year of Stay (Excluding Prior Proximal) (Reference group: 0)									
n_priors_00	0 (Reference)	2,230,680	54.5	-	-	-	-	-	-
n_priors_01	1	981,350	24.0	0.298	0.007	<.0001	1.35	1.33	1.37
n_priors_02	2	432,531	10.6	0.531	0.009	<.0001	1.70	1.67	1.73
n_priors_03	3	209,182	5.1	0.722	0.010	<.0001	2.06	2.02	2.10
n_priors_04	4	106,045	2.6	0.889	0.012	<.0001	2.43	2.37	2.49
n_priors_05	5	56,574	1.4	1.068	0.015	<.0001	2.91	2.83	3.00
n_priors_06	6	31,310	0.8	1.218	0.018	<.0001	3.38	3.26	3.50
n_priors_07	7	17,834	0.4	1.301	0.023	<.0001	3.67	3.51	3.84
n_priors_08	8	10,562	0.3	1.384	0.028	<.0001	3.99	3.78	4.22
n_priors_09	9	6,297	0.2	1.570	0.034	<.0001	4.81	4.50	5.14
n_priors_10	10+	11,896	0.3	1.774	0.024	<.0001	5.90	5.62	6.18
Number of Outpatient Emergency Department Visits within One Year of Stay (Reference group: 0)									
-	0 (Reference)	2,410,181	58.9	-	-	-	-	-	-
prior_er	≥ 1	1,684,080	41.1	0.120	0.006	<.0001	1.13	1.12	1.14
CCS Diagnosis Groups (Reference group: CCS 203: Osteoarthritis)									
dgn_002	2 - Septicemia (except in labor)	169,526	4.1	0.852	0.037	<.0001	2.34	2.18	2.52
dgn_004	4 - Mycoses	3,307	0.1	0.930	0.076	<.0001	2.53	2.18	2.94
dgn_047	47 - Other and unspecified benign neoplasm	13,334	0.3	0.285	0.078	0.0003	1.33	1.14	1.55
dgn_050	50 - Diabetes mellitus with complications	62,379	1.5	0.848	0.040	<.0001	2.33	2.16	2.53
dgn_055	55 - Fluid and electrolyte disorders	57,793	1.4	0.830	0.040	<.0001	2.29	2.12	2.48
dgn_059	59 - Deficiency and other anemia	23,343	0.6	0.725	0.046	<.0001	2.06	1.89	2.26
dgn_083	83 - Epilepsy; convulsions	21,281	0.5	0.341	0.054	<.0001	1.41	1.27	1.56
dgn_099	99 - Hypertension with complications and secondary hypertension	37,334	0.9	0.947	0.041	<.0001	2.58	2.38	2.79
dgn_100	100 - Acute myocardial infarction	88,284	2.2	0.819	0.039	<.0001	2.27	2.10	2.45
dgn_102	102 - Nonspecific chest pain	20,559	0.5	0.642	0.048	<.0001	1.90	1.73	2.09
dgn_106	106 - Cardiac dysrhythmias	117,725	2.9	0.871	0.038	<.0001	2.39	2.22	2.57

Variable Name in Model	Covariate	Count	Percent Total	Estimate	Std. Error	P value	Odds Ratio	OR 95% Lower CL	OR 95% Upper CL
dgn_108	108 - Congestive heart failure; nonhypertensive	205,862	5.0	1.115	0.036	<.0001	3.05	2.84	3.28
dgn_109	109 - Acute cerebrovascular disease	128,999	3.2	0.451	0.040	<.0001	1.57	1.45	1.70
dgn_115	115 - Aortic; peripheral; and visceral artery aneurysms	18,001	0.4	0.368	0.062	<.0001	1.45	1.28	1.63
dgn_117	117 - Other circulatory disease	25,577	0.6	0.655	0.047	<.0001	1.92	1.75	2.11
dgn_122	122 - Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	171,852	4.2	0.839	0.037	<.0001	2.31	2.15	2.49
dgn_127	127 - Chronic obstructive pulmonary disease and bronchiectasis	126,843	3.1	1.210	0.037	<.0001	3.35	3.12	3.60
dgn_128	128 - Asthma	27,155	0.7	1.183	0.042	<.0001	3.26	3.01	3.54
dgn_129	129 - Aspiration pneumonitis; food/vomitus	26,381	0.6	0.919	0.044	<.0001	2.51	2.30	2.73
dgn_131	131 - Respiratory failure; insufficiency; arrest (adult)	53,781	1.3	0.913	0.039	<.0001	2.49	2.31	2.69
dgn_133	133 - Other lower respiratory disease	13,632	0.3	0.770	0.053	<.0001	2.16	1.95	2.40
dgn_135	135 - Intestinal infection	26,596	0.6	0.959	0.043	<.0001	2.61	2.40	2.84
dgn_143	143 - Abdominal hernia	29,097	0.7	0.329	0.066	<.0001	1.39	1.22	1.58
dgn_146	146 - Diverticulosis and diverticulitis	38,014	0.9	0.434	0.049	<.0001	1.54	1.40	1.70
dgn_157	157 - Acute and unspecified renal failure	86,957	2.1	0.909	0.038	<.0001	2.48	2.30	2.67
dgn_159	159 - Urinary tract infections	101,243	2.5	0.937	0.038	<.0001	2.55	2.37	2.75
dgn_161	161 - Other diseases of kidney and ureters	3,759	0.1	0.805	0.082	<.0001	2.24	1.91	2.63
dgn_197	197 - Skin and subcutaneous tissue infections	87,978	2.1	0.907	0.039	<.0001	2.48	2.30	2.67
dgn_199	199 - Chronic ulcer of skin	7,806	0.2	0.938	0.061	<.0001	2.56	2.27	2.88
dgn_203	203 - Osteoarthritis (Reference)	568,390	13.9%	-	-	-	-	-	-
dgn_205	205 - Spondylosis; intervertebral disc disorders; other back problems	113,872	2.8	0.413	0.049	<.0001	1.51	1.37	1.66
dgn_229	229 - Fracture of upper limb	27,931	0.7	0.308	0.065	<.0001	1.36	1.20	1.55
dgn_230	230 - Fracture of lower limb	39,763	1.0	0.239	0.066	0.0003	1.27	1.12	1.44
dgn_231	231 - Other fractures	62,967	1.5	0.339	0.045	<.0001	1.40	1.28	1.53
dgn_238	238 - Complications of surgical procedures or medical care	69,918	1.7	0.284	0.042	<.0001	1.33	1.22	1.44
dgn_254	254 - Rehabilitation care; fitting of prostheses; and adjustment of devices	10,282	0.3	-0.260	0.082	0.0014	0.77	0.66	0.90
dgn_657	657 - Mood disorders	21,428	0.5	0.220	0.054	<.0001	1.25	1.12	1.38
dgn_659	659 - Schizophrenia and other psychotic disorders	13,541	0.3	0.098	0.064	0.1228	1.10	0.97	1.25
dgn_misc	Composite of all other CCS diagnosis groups	1,940,161	47.4	0.553	0.035	<.0001	1.74	1.62	1.86
CCS Procedure Groups (Reference group: Composite of all other CCS procedure groups)									
prc_001	1 - Incision and excision of CNS	11,318	0.3	-0.252	0.075	0.0008	0.78	0.67	0.90
prc_002	2 - Insertion; replacement; or removal of extracranial ventricular shunt	4,150	0.1	-0.674	0.136	<.0001	0.51	0.39	0.67

Variable Name in Model	Covariate	Count	Percent Total	Estimate	Std. Error	P value	Odds Ratio	OR 95% Lower CL	OR 95% Upper CL
prc_003	3 - Laminectomy; excision intervertebral disc	81,809	2.0	-0.503	0.047	<.0001	0.60	0.55	0.66
prc_004	4 - Diagnostic spinal tap	20,654	0.5	-0.146	0.039	0.0002	0.86	0.80	0.93
prc_009	9 - Other OR therapeutic nervous system procedures	21,011	0.5	-0.268	0.068	<.0001	0.77	0.67	0.87
prc_036	36 - Lobectomy or pneumonectomy	4,846	0.1	-0.535	0.095	<.0001	0.59	0.49	0.71
prc_042	42 - Other OR Rx procedures on respiratory system and mediastinum	14,206	0.3	-0.223	0.050	<.0001	0.80	0.73	0.88
prc_044	44 - Coronary artery bypass graft (CABG)	97,103	2.4	-0.312	0.032	<.0001	0.73	0.69	0.78
prc_048	48 - Insertion; revision; replacement; removal of cardiac pacemaker or cardioverter/defibrillator	74,246	1.8	-0.195	0.020	<.0001	0.82	0.79	0.86
prc_050	50 - Extracorporeal circulation auxiliary to open heart procedures	121,946	3.0	-0.348	0.028	<.0001	0.71	0.67	0.75
prc_051	51 - Endarterectomy; vessel of head and neck	13,036	0.3	-0.307	0.067	<.0001	0.74	0.65	0.84
prc_055	55 - Peripheral vascular bypass	19,588	0.5	-0.327	0.048	<.0001	0.72	0.66	0.79
prc_057	57 - Creation; revision and removal of arteriovenous fistula or vessel-to-vessel cannula for dialysis	8,133	0.2	-0.139	0.047	0.0032	0.87	0.79	0.95
prc_061	61 - Other OR procedures on vessels other than head and neck	141,417	3.5	-0.099	0.016	<.0001	0.91	0.88	0.94
prc_065	65 - Bone marrow biopsy	7,078	0.2	0.099	0.053	0.0596	1.10	1.00	1.22
prc_072	72 - Colostomy; temporary and permanent	13,187	0.3	-0.311	0.076	<.0001	0.73	0.63	0.85
prc_075	75 - Small bowel resection	17,177	0.4	-0.115	0.058	0.0470	0.89	0.80	1.00
prc_078	78 - Colorectal resection	38,869	0.9	-0.205	0.044	<.0001	0.81	0.75	0.89
prc_080	80 - Appendectomy	9,679	0.2	-0.580	0.090	<.0001	0.56	0.47	0.67
prc_084	84 - Cholecystectomy and common duct exploration	35,617	0.9	-0.436	0.039	<.0001	0.65	0.60	0.70
prc_086	86 - Other hernia repair	31,932	0.8	-0.336	0.057	<.0001	0.71	0.64	0.80
prc_090	90 - Excision; lysis peritoneal adhesions	42,446	1.0	-0.171	0.039	<.0001	0.84	0.78	0.91
prc_091	91 - Peritoneal dialysis	4,671	0.1	0.149	0.058	0.0100	1.16	1.04	1.30
prc_094	94 - Other OR upper GI therapeutic procedures	10,725	0.3	-0.357	0.073	<.0001	0.70	0.61	0.81
prc_096	96 - Other OR lower GI therapeutic procedures	36,818	0.9	-0.193	0.039	<.0001	0.82	0.76	0.89
prc_098	98 - Other non-OR gastrointestinal therapeutic procedures	27,182	0.7	-0.135	0.036	0.0002	0.87	0.81	0.94
prc_099	99 - Other OR gastrointestinal therapeutic procedures	23,004	0.6	-0.128	0.044	0.0036	0.88	0.81	0.96
prc_103	103 - Nephrotomy and nephrostomy	6,811	0.2	0.420	0.049	<.0001	1.52	1.38	1.68
prc_105	105 - Kidney transplant	4,140	0.1	-0.329	0.087	0.0001	0.72	0.61	0.85
prc_110	110 - Other diagnostic procedures of urinary tract	3,496	0.1	0.270	0.068	<.0001	1.31	1.14	1.50
prc_111	111 - Other non-OR therapeutic procedures of urinary tract	11,344	0.3	0.156	0.041	0.0002	1.17	1.08	1.27
prc_124	124 - Hysterectomy; abdominal and vaginal	4,058	0.1	-0.825	0.165	<.0001	0.44	0.32	0.61
prc_142	142 - Partial excision bone	70,504	1.7	-0.133	0.039	0.0006	0.88	0.81	0.94

Variable Name in Model	Covariate	Count	Percent Total	Estimate	Std. Error	P value	Odds Ratio	OR 95% Lower CL	OR 95% Upper CL
prc_145	145 - Treatment; fracture or dislocation of radius and ulna	10,797	0.3	-0.445	0.095	<.0001	0.64	0.53	0.77
prc_146	146 - Treatment; fracture or dislocation of hip and femur	96,452	2.4	-0.400	0.030	<.0001	0.67	0.63	0.71
prc_147	147 - Treatment; fracture or dislocation of lower extremity (other than hip or femur)	31,283	0.8	-0.600	0.067	<.0001	0.55	0.48	0.63
prc_148	148 - Other fracture and dislocation procedure	31,484	0.8	-0.222	0.054	<.0001	0.80	0.72	0.89
prc_152	152 - Arthroplasty knee	416,453	10.2	-0.985	0.037	<.0001	0.37	0.35	0.40
prc_153	153 - Hip replacement; total and partial	258,714	6.3	-0.830	0.031	<.0001	0.44	0.41	0.46
prc_154	154 - Arthroplasty other than hip or knee	34,062	0.8	-0.739	0.065	<.0001	0.48	0.42	0.54
prc_157	157 - Amputation of lower extremity	27,716	0.7	-0.428	0.035	<.0001	0.65	0.61	0.70
prc_158	158 - Spinal fusion	91,410	2.2	-0.659	0.049	<.0001	0.52	0.47	0.57
prc_160	160 - Other therapeutic procedures on muscles and tendons	51,352	1.3	-0.152	0.031	<.0001	0.86	0.81	0.91
prc_162	162 - Other OR therapeutic procedures on joints	33,348	0.8	-0.307	0.047	<.0001	0.74	0.67	0.81
prc_168	168 - Incision and drainage; skin and subcutaneous tissue	37,627	0.9	-0.191	0.030	<.0001	0.83	0.78	0.88
prc_172	172 - Skin graft	12,303	0.3	-0.323	0.058	<.0001	0.72	0.65	0.81
prc_176	176 - Organ transplantation (other than bone marrow, corneal or kidney)	1,926	0.0	-0.486	0.127	0.0001	0.62	0.48	0.79
prc_193	193 - Diagnostic ultrasound of heart (echocardiogram)	181,185	4.4	-0.031	0.013	0.0181	0.97	0.94	0.99
prc_198	198 - Magnetic resonance imaging	33,099	0.8	-0.109	0.035	0.0017	0.90	0.84	0.96
prc_211	211 - Radiation therapy	4,097	0.1	0.236	0.077	0.0021	1.27	1.09	1.47
prc_214	214 - Traction; splints; and other wound care	19,085	0.5	-0.119	0.047	0.0114	0.89	0.81	0.97
prc_224	224 - Cancer chemotherapy	2,660	0.1	0.220	0.076	0.0039	1.25	1.07	1.45
prc_231	231 - Other therapeutic procedures	210,299	5.1	-0.001	0.013	0.9275	1.00	0.97	1.02
HCC Comorbidities									
hcc_7	7 - Metastatic Cancer and Acute Leukemia	126,591	3.1	0.268	0.013	<.0001	1.31	1.27	1.34
hcc_8	8 - Lung, Upper Digestive Tract, and Other Severe Cancers	94,622	2.3	0.164	0.015	<.0001	1.18	1.15	1.21
hcc_9	9 - Lymphatic, Head and Neck, Brain, and Other Major Cancers	124,787	3.0	0.120	0.014	<.0001	1.13	1.10	1.16
hcc_15	15 - Diabetes with Renal or Peripheral Circulatory Manifestation	432,291	10.6	0.137	0.009	<.0001	1.15	1.13	1.17
hcc_16	16 - Diabetes with Neurologic or Other Specified Manifestation	326,691	8.0	0.125	0.009	<.0001	1.13	1.11	1.15
hcc_18	18 - Diabetes with Ophthalmologic or Unspecified Manifestation	78,403	1.9	0.105	0.019	<.0001	1.11	1.07	1.15
hcc_19	19 - Diabetes without Complication	906,205	22.1	0.050	0.007	<.0001	1.05	1.04	1.07
hcc_21	21 - Protein-Calorie Malnutrition	373,387	9.1	0.041	0.008	<.0001	1.04	1.02	1.06
hcc_26	26 - Cirrhosis of Liver	46,587	1.1	0.061	0.021	0.0029	1.06	1.02	1.11

Variable Name in Model	Covariate	Count	Percent Total	Estimate	Std. Error	P value	Odds Ratio	OR 95% Lower CL	OR 95% Upper CL
hcc_31	31 - Intestinal Obstruction/Perforation	309,792	7.6	-0.155	0.010	<.0001	0.86	0.84	0.87
hcc_37	37 - Bone/Joint/Muscle Infections/Necrosis	199,623	4.9	-0.048	0.013	0.0002	0.95	0.93	0.98
hcc_44	44 - Severe Hematological Disorders	102,295	2.5	0.087	0.014	<.0001	1.09	1.06	1.12
hcc_45	45 - Disorders of Immunity	106,560	2.6	0.052	0.014	0.0003	1.05	1.02	1.08
hcc_51	51 - Drug/Alcohol Psychosis	103,178	2.5	-0.070	0.016	<.0001	0.93	0.90	0.96
hcc_52	52 - Drug/Alcohol Dependence	119,056	2.9	0.065	0.014	<.0001	1.07	1.04	1.10
hcc_73	73 - Parkinson's and Huntington's Diseases	134,918	3.3	0.056	0.014	<.0001	1.06	1.03	1.09
hcc_75	75 - Coma, Brain Compression/Anoxic Damage	53,420	1.3	-0.095	0.021	<.0001	0.91	0.87	0.95
hcc_79	79 - Cardio-Respiratory Failure and Shock	1,000,737	24.4	0.093	0.006	<.0001	1.10	1.08	1.11
hcc_80	80 - Congestive Heart Failure	1,726,889	42.2	0.290	0.007	<.0001	1.34	1.32	1.35
hcc_83	83 - Angina Pectoris/Old Myocardial Infarction	492,741	12.0	0.041	0.007	<.0001	1.04	1.03	1.06
hcc_92	92 - Specified Heart Arrhythmias	1,538,209	37.6	0.122	0.006	<.0001	1.13	1.12	1.14
hcc_95	95 - Cerebral Hemorrhage	103,915	2.5	-0.157	0.020	<.0001	0.86	0.82	0.89
hcc_96	96 - Ischemic or Unspecified Stroke	536,202	13.1	-0.071	0.008	<.0001	0.93	0.92	0.95
hcc_100	100 - Hemiplegia/Hemiparesis	202,324	4.9	-0.061	0.013	<.0001	0.94	0.92	0.96
hcc_105	105 - Vascular Disease	1,231,932	30.1	0.033	0.006	<.0001	1.03	1.02	1.05
hcc_108	108 - Chronic Obstructive Pulmonary Disease	1,491,517	36.4	0.236	0.006	<.0001	1.27	1.25	1.28
hcc_111	111 - Aspiration and Specified Bacterial Pneumonias	215,738	5.3	0.041	0.010	<.0001	1.04	1.02	1.06
hcc_119	119 - Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	59,011	1.4	0.030	0.019	0.1102	1.03	0.99	1.07
hcc_130	130 - Dialysis Status	92,322	2.3	0.252	0.016	<.0001	1.29	1.25	1.33
hcc_131	131 - Renal Failure	1,440,388	35.2	0.215	0.006	<.0001	1.24	1.22	1.25
hcc_148	148 - Decubitus Ulcer of Skin	205,493	5.0	0.126	0.010	<.0001	1.13	1.11	1.16
hcc_149	149 - Chronic Ulcer of Skin, Except Decubitus	196,260	4.8	0.136	0.011	<.0001	1.15	1.12	1.17
hcc_155	155 - Major Head Injury	109,012	2.7	-0.103	0.019	<.0001	0.90	0.87	0.94
hcc_158	158 - Hip Fracture/Dislocation	310,691	7.6	-0.149	0.013	<.0001	0.86	0.84	0.88
hcc_161	161 - Traumatic Amputation	27,930	0.7	-0.076	0.027	0.0052	0.93	0.88	0.98
hcc_164	164 - Major Complications of Medical Care and Trauma	580,484	14.2	-0.081	0.008	<.0001	0.92	0.91	0.94
hcc_176	176 - Artificial Openings for Feeding or Elimination	132,042	3.2	0.101	0.013	<.0001	1.11	1.08	1.13
hcc_177	177 - Amputation Status, Lower Limb/Amputation Complications	63,566	1.6	0.057	0.018	0.0016	1.06	1.02	1.10