NATIONAL QUALITY FORUM—Composite Measure Testing (subcriteria 2a2, 2b1-2b6)

**Measure Number** (*if previously endorsed*)**:** 531

**Composite Measure Title**: Patient Safety Indicator (PSI) 90: Patient Safety and Adverse Events Composite

**Date of Submission**: July 31, 2020

# Composite Construction:

Two or more individual performance measure scores combined into one score

□ All-or-none measures (e.g., all essential care processes received or outcomes experienced by each patient)

# Instructions: Please contact NQF staff before you begin.

* If a component measure is submitted as an individual performance measure, the non-composite measure testing form must also be completed and attached to the individual measure submission.
* Measures must be tested for all the data sources and levels of analyses that are specified. ***If there is more than one set of data specifications or more than one level of analysis, contact NQF staff*** about how to present all the testing information in one form.

# Sections 1, 2a2, 2b1, 2b2, and 2b4 must be completed.

* **For composites with outcome and resource use measures**, section **2b3** also must be completed.
* If specified for **multiple data sources/sets of specificaitons** (e.g., claims and EHRs), section **2b5** also must be completed.
* Respond to all questions as instructed with answers immediately following the question. All information on testing to demonstrate meeting the subcriteria for reliability (2a2) and validity (2b1-2b6) and composites (2c) must be in this form. An appendix for *supplemental* materials may be submitted, but there is no guarantee it will be reviewed.
* If you are unable to check a box, please highlight or shade the box for your response.
* Maximum of 25 pages (*incuding questions/instructions;* minimum font size 11 pt; do not change margins).

## Contact NQF staff if more pages are needed.

* Contact NQF staff regarding questions. Check for resources at [Submitting Standards webpage](http://www.qualityforum.org/Measuring_Performance/Submitting_Standards.aspx).
* For information on the most updated guidance on how to address social risk factors variables and testing in this form refer to the release notes for version 7.1 of the Measure Testing Attachment. and the 2017 Measure Evaluation Criteria and Guidance.

**Note:** The information provided in this form is intended to aid the Standing Committee and other stakeholders in understanding to what degree the testing results for this measure meet NQF’s evaluation criteria for testing.

**2a2. Reliability testing** [**10**](#_bookmark0) demonstrates the measure data elements are repeatable, producing the same results a high proportion of the time when assessed in the same population in the same time period and/or that the measure score is precise. For **instrument-based measures** (including **PRO-PMs**) **and composite performance measures**, reliability should be demonstrated for the computed performance score.

**2b1. Validity testing** [**11**](#_bookmark1) demonstrates that the measure data elements are correct and/or the measure score correctly reflects the quality of care provided, adequately identifying differences in quality. For **instrument based measures (including PRO-PMs) and composite performance measures**, validity should be demonstrated for the computed performance score.

**2b2.** Exclusions are supported by the clinical evidenceand are of sufficient frequency to warrant inclusion in the specifications of the measure; [**12**](#_bookmark2)

# AND

If patient preference (e.g., informed decisionmaking) is a basis for exclusion, there must be evidence that the exclusion impacts performance on the measure; in such cases, the measure must be specified so that the information about patient preference and the effect on the measure is transparent (e.g., numerator category computed separately, denominator exclusion category computed separately). [**13**](#_bookmark3)

**2b3. For outcome measures and other measures when indicated** (e.g., resource use):

* **an evidence-based risk-adjustment strategy** (e.g., risk models, risk stratification) is specified; is based on patient factors (including clinical and social risk factors) that influence the measured outcome and are present at start of care; [**14,15**](#_bookmark4) and has demonstrated adequate discrimination and calibration

# OR

* rationale/data support no risk adjustment/ stratification.

**2b4.** Data analysis of computed measure scores demonstrates that methods for scoring and analysis of the specified measure allow for **identification of statistically significant and practically/clinically meaningful** [**16**](#_bookmark5) **differences in performance**;

# OR

there is evidence of overall less-than-optimal performance.

# 2b5. If multiple data sources/methods are specified, there is demonstration they produce comparable results.

**2b6.** Analyses identify the extent and distribution of **missing data** (or nonresponse) and demonstrate that performance results are not biased due to systematic missing data (or differences between responders and nonresponders) and how the specified handling of missing data minimizes bias.

# 2c. For composite performance measures, empirical analyses support the composite construction approach and demonstrate that:

**2c1.** the component measures fit the quality construct and add value to the overall composite while achieving the related objective of parsimony to the extent possible; and

**2c2**.the aggregation and weighting rules are consistent with the quality construct and rationale while achieving the related objective of simplicity to the extent possible.

(*if not conducted or results not adequate, justification must be submitted and accepted)*

**Notes**

1. Reliability testing applies to both the data elements and computed measure score. Examples of reliability testing for data elements include, but are not limited to: inter-rater/abstractor or intra-rater/abstractor studies; internal consistency for multi-item scales; test-retest for survey items. Reliability testing of the measure score addresses precision of measurement (e.g., signal-to-noise).
2. Validity testing applies to both the data elements and computed measure score. Validity testing of data elements typically analyzes agreement with another authoritative source of the same information. Examples of validity testing of the measure score include, but are not limited to: testing hypotheses that the measures scores indicate quality of care, e.g., measure scores are different for groups known to have differences in quality assessed by another valid quality measure or method; correlation of measure scores with another valid indicator of quality for the specific topic; or relationship to conceptually related measures (e.g., scores on process measures to scores on outcome measures). Face validity of the measure score as a quality indicator may be adequate if accomplished through a systematic and transparent process, by identified experts, and explicitly addresses whether performance scores resulting from the measure as specified can be

used to distinguish good from poor quality. The degree of consensus and any areas of disagreement must be provided/discussed.

1. Examples of evidence that an exclusion distorts measure results include, but are not limited to: frequency of occurrence, variability of exclusions across providers, and sensitivity analyses with and without the exclusion.
2. Patient preference is not a clinical exception to eligibility and can be influenced by provider interventions.
3. Risk factors that influence outcomes should not be specified as exclusions.
4. With large enough sample sizes, small differences that are statistically significant may or may not be practically or clinically meaningful. The substantive question may be, for example, whether a statistically significant difference of one percentage point in the percentage of patients who received smoking cessation counseling (e.g., 74 percent v. 75 percent) is clinically meaningful; or whether a statistically significant difference of $25 in cost for an episode of care (e.g., $5,000 v.

$5,025) is practically meaningful. Measures with overall less-than-optimal performance may not demonstrate much variability across providers.

# DATA/SAMPLE USED FOR ALL TESTING OF THIS MEASURE

*Often the same data are used for all aspects of measure testing. In an effort to eliminate duplication, the first five questions apply to all measure testing. If there are differences by aspect of testing,(e.g., reliability vs. validity) be sure to indicate the specific differences in question 1.7.*

* + 1. **What type of data was used for testing**? (*Check all the sources of data identified in the measure specifications and data used for testing the measure*. *Testing must be provided for all the sources of data specified and intended for measure implementation.* ***If different data sources are used for different components in the composite, indicate the component after the checkbox. If different data sources are used for the numerator and denominator, indicate N [numerator] or D [denominator] after the checkbox.***)

|  |  |
| --- | --- |
| **Measure Specified to Use Data From:**  **(*must be consistent with data sources entered in S.17*)** | **Measure Tested with Data From:** |
| □ abstracted from paper record | □ abstracted from paper record |
| claims | claims |
| □ registry | □ registry |
| □ abstracted from electronic health record | □ abstracted from electronic health record |
| □ eMeasure (HQMF) implemented in EHRs | □ eMeasure (HQMF) implemented in EHRs |
| □ other: Click here to describe | □ other: Click here to describe |

* + 1. **If an existing dataset was used, identify the specific dataset** (*the dataset used for testing must be consistent with the measure specifications for target population and healthcare entities being measured; e.g., Medicare Part A claims, Medicaid claims, other commercial insurance, nursing home MDS, home health OASIS, clinical registry*).

Most analyses were completed using Medicare Fee-for-Service (FFS) discharge data from Inpatient Prospective Payment System (IPPS) hospitals, incuding hospitals in Maryland and exluding Veteran’s Administration Hospitals, from July 1, 2016 – June 30, 2019. The files included monthly inpatient (Part A) claims files[[1]](#footnote-2) (Research Identifiable Files, or RIF) and Medicare Beneficiary Summary Files[[2]](#footnote-3) from 2016 to 2019. These files contain diagnosis codes (ICD-10-CM), procedure codes (ICD-10-PCS), dates of service, cost and revenue codes, provider identifiers and beneficiary information. The final dataset included 13,611,933 individuals, 3345 hospitals, and 28,745,550 hospital stays.

Confirmatory testing was completed using selected Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases (SID), because these data supported NQF’s previous endorsement of PSI 90. HCUP is a family of health care databases and related software tools and products developed through a Federal-State-Industry partnership and sponsored by the Agency for Healthcare Research and Quality (AHRQ).[[3]](#footnote-4) The HCUP SID contain all inpatient discharge abstracts from nonfederal acute care hospitals in participating States, translated into a uniform format to facilitate multi-State comparisons and analyses. For the analyses presented here, we used 2016-2017 data from Arizona, Florida, Kentucky, Nevada, Maryland, Washington, Maine, Minnesota and Nebraska, which include 13,390,121 hospital discharges. These data sets were selected because they had all necessary data elements (i.e., “present on admission” flag for each diagnosis code, procedure dates, de-identified hospital identifiers), were readily available through the HCUP Central Distributor, and offered geographic diversity at a reasonable cost.

* + 1. **What are the dates of the data used in testing?**

July 1, 2016 – June 30, 2019 CMS data; January 1, 2016 – December 31, 2017 HCUP data

* + 1. **What levels of analysis were tested**? (*testing must be provided for all the levels specified and intended for measure implementation, e.g., individual clinician, hospital, health plan*)

|  |  |
| --- | --- |
| **Measure Specified to Measure Performance of: (*must be consistent with levels entered in item S.20*)** | **Measure Tested at Level of:** |
| □ individual clinician | □ individual clinician |
| □ group/practice | □ group/practice |
| hospital/facility/agency | hospital/facility/agency |
| □ health plan | □ health plan |
| □ other: Click here to describe | □ other: Click here to describe |

* + 1. **How many and which measured entities were included in the testing and analysis (by level of analysis and data source)**? (*identify the number and descriptive characteristics of measured entities included in the analysis (e.g., size, location, type); if a sample was used, describe how entities were selected for inclusion in the sample*)

**Table 1. Number and Descriptive Characteristics of Hospitals Included in Testing and Analysis, Medicare Fee-for-Service 2016-2019 and HCUP SID 2016-2017 (9 States)**

| **Hospital Category** | **Medicare FFS Data (7/1/2016-6/30/2017)** | **Medicare FFS Data**  **(7/1/2017-6/30/2018)** | **Medicare FFS Data**  **(7/1/2018-6/30/2019)** | **HCUP All-Payer SID Data (1/1/2016- 12/31/2016)** | **HCUP All-Payer SID Data (1/1/2017- 12/31/2017)** |
| --- | --- | --- | --- | --- | --- |
| Investor Owned;  <100 beds | 304 | 307 | 300 | 127 | 124 |
| Investor Owned;  >100 beds | 460 | 455 | 448 | 118 | 117 |
| Not-for-Profit (Rural); <100 beds | 407 | 392 | 381 | 114 | 114 |
| Not-for-Profit (Rural); >100 beds | 236 | 236 | 236 | 23 | 23 |
| Not-for-Profit (Urban); <100 beds | 332 | 333 | 335 | 101 | 101 |
| Not-for-Profit (Urban); 100-299 beds | 781 | 779 | 769 | 113 | 120 |
| Not-for-Profit (Urban); >300 beds | 751 | 752 | 750 | 97 | 98 |
| **Total** | **3,271** | **3,254** | **3,219** | **693** | **697** |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with CMS v10.0 software.*

*HCUP all-payer discharges (1/1/2016-12/31/2017) for AZ, FL, KY, MD, ME, MN, NE, NV, WA, processed with AHRQ v2019 software.*

* + 1. **How many and which patients were included in the testing and analysis (by level of analysis and data source)**? (*identify the number and descriptive characteristics of patients included in the analysis (e.g., age, sex, race, diagnosis); if a sample was used, describe how patients were selected for inclusion in the sample*)

**Table 2. Number of Patients Included in Testing and Analysis, by PSI 90 Component Indicator, Medicare Fee-for-Service 2016-2019 and HCUP SID 2016-2017 (9 States)**

| **PSIs** | **Medicare FFS Data**  **(7/1/2016-6/30/2017)** | **Medicare FFS Data**  **(7/1/2017-6/30/2018)** | **Medicare FFS Data**  **(7/1/2018-6/30/2019)** | **HCUP All-Payer SID Data (1/1/2016- 12/31/2016)** | **HCUP All-Payer SID Data (1/1/2017- 12/31/2017)** |
| --- | --- | --- | --- | --- | --- |
| PSI 03 | 6,828,538 | 6,715,206 | 6,535,165 | 3,182,123 | 3,199,669 |
| PSI 06 | 8,993,318 | 8,861,590 | 8,643,702 | 4,699,253 | 4,748,375 |
| PSI 08 | 7,894,667 | 7,792,221 | 7,564,793 | 3,935,755 | 3,982,230 |
| PSI 09 | 2,401,432 | 2,350,443 | 2,310,743 | 1,278,901 | 1,277,930 |
| PSI 10 | 1,347,526 | 1,305,634 | 1,251,666 | 692,952 | 692,588 |
| PSI 11 | 1,099,250 | 1,056,932 | 1,006,536 | 589,062 | 587,112 |
| PSI 12 | 2,568,511 | 2,511,226 | 2,461,097 | 1,360,406 | 1,353,880 |
| PSI 13 | 1,316,120 | 6,715,206 | 1,222,407 | 669,705 | 670,366 |
| PSI 14A | 270,185 | 262,204 | 258,029 | 167,207 | 165,728 |
| PSI 14B | 286,560 | 282,060 | 281,217 | 195,140 | 190,897 |
| PSI 15 | 1,589,209 | 1,561,479 | 1,537,324 | 868,142 | 868,733 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with CMS v10.0 software.*

*HCUP all-payer discharges (1/1/2016-12/31/2017) for AZ, FL, KY, MD, ME, MN, NE, NV, WA, processed with AHRQ v2019 software.*

*Notes: PSI 14A reflects postoperative wound dehiscence with an open approach and PSI 14B reflects non-open approach.*

**Table 3A. Descriptive Characteristics of Patients Included in Testing and Analysis, by PSI 90 Component Indicator, Medicare Fee-for-Service Population (2016-2019)**

| **PSI** | **Male (%)** | **Female (%)** | **Mean**  **age** | **Median**  **age** | **Age (SD)** | **White (%)** | **Black (%)** | **Hispanic (%)** | **API (%)** | **Native Amer (%)** | **Other (%)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PSI 03 | 45.7 | 54.4 | 73.1 | 74.0 | 13.3 | 80.4 | 13.0 | 2.3 | 1.5 | 0.7 | 1.2 |
| PSI 06 | 45.9 | 54.1 | 72.7 | 74.0 | 13.3 | 80.5 | 12.9 | 2.3 | 1.4 | 0.8 | 1.2 |
| PSI 08 | 46.4 | 53.6 | 72.5 | 73.0 | 13.1 | 80.4 | 13.0 | 2.3 | 1.4 | 0.8 | 1.2 |
| PSI 09 | 47.1 | 52.9 | 71.5 | 72.0 | 11.1 | 84.6 | 9.3 | 1.8 | 1.1 | 0.7 | 1.2 |
| PSI 10 | 45.6 | 54.4 | 70.8 | 71.0 | 9.5 | 87.3 | 7.3 | 1.3 | 0.9 | 0.6 | 1.1 |
| PSI 11 | 42.5 | 57.5 | 70.1 | 70.0 | 9.6 | 86.9 | 7.5 | 1.3 | 0.9 | 0.6 | 1.1 |
| PSI 12 | 47.8 | 52.2 | 71.5 | 72.0 | 11.2 | 84.4 | 9.4 | 1.8 | 1.1 | 0.7 | 1.2 |
| PSI 13 | 45.8 | 54.2 | 70.8 | 71.0 | 9.5 | 87.0 | 7.5 | 1.3 | 0.9 | 0.6 | 1.1 |
| PSI 14A | 45.3 | 54.7 | 71.1 | 71.0 | 10.8 | 85.1 | 9.1 | 1.6 | 1.1 | 0.6 | 1.2 |
| PSI 14B | 49.4 | 50.7 | 70.7 | 71.0 | 11.7 | 82.9 | 9.5 | 2.5 | 1.5 | 0.8 | 1.5 |
| PSI 15 | 49.8 | 50.2 | 71.5 | 72.0 | 12.4 | 80.1 | 12.6 | 2.4 | 1.6 | 0.7 | 1.4 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with CMS v10.0 software.*

*Notes: PSI 14A reflects postoperative wound dehiscence with an open approach and PSI 14B reflects non-open approach.*

*Abbreviations: SD=standard deviation; API=Asian or Pacific Islander*

**Table 3B. Descriptive Characteristics of Patients Included in Testing and Analysis, by PSI 90 Component Indicator, HCUP SID Population (2016) from 9 States**

| **PSI** | **Male (%)** | **Female (%)** | **Mean**  **age** | **Median**  **age** | **Age (SD)** | **White (%)** | **Black (%)** | **Hispanic (%)** | **API (%)** | **Native Amer (%)** | **Other (%)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PSI 03 | 48.6 | 51.4 | 63.3 | 65.0 | 18.3 | 70.9 | 12.5 | 9.4 | 1.3 | 0.8 | 5.0 |
| PSI 06 | 48.6 | 51.4 | 61.8 | 64.0 | 18.5 | 70.7 | 12.5 | 9.8 | 1.3 | 0.8 | 5.0 |
| PSI 08 | 48.1 | 51.9 | 62.7 | 65.0 | 17.8 | 71.2 | 12.3 | 9.8 | 1.3 | 0.8 | 4.8 |
| PSI 09 | 48.3 | 51.7 | 61.7 | 64.0 | 16.1 | 73.9 | 9.1 | 9.1 | 1.2 | 0.7 | 6.0 |
| PSI 10 | 44.9 | 55.1 | 62.4 | 64.0 | 14.1 | 77.4 | 7.6 | 6.3 | 1.1 | 0.5 | 7.1 |
| PSI 11 | 42.2 | 57.8 | 61.4 | 63.0 | 14.1 | 77.1 | 7.9 | 6.4 | 1.1 | 0.5 | 7.0 |
| PSI 12 | 49.0 | 51.0 | 62.0 | 64.0 | 16.0 | 73.8 | 9.1 | 9.1 | 1.3 | 0.7 | 6.0 |
| PSI 13 | 44.9 | 55.1 | 62.5 | 64.0 | 14.1 | 77.2 | 7.7 | 6.3 | 1.1 | 0.5 | 7.2 |
| PSI 14A | 42.9 | 57.1 | 59.5 | 61.0 | 16.1 | 70.3 | 11.3 | 9.7 | 1.4 | 0.7 | 6.6 |
| PSI 14B | 45.8 | 54.2 | 57.8 | 59.0 | 17.0 | 68.6 | 10.1 | 13.5 | 1.6 | 0.9 | 5.3 |
| PSI 15 | 47.6 | 52.4 | 60.6 | 62.0 | 17.2 | 69.4 | 11.6 | 11.2 | 1.5 | 0.8 | 5.5 |

*Source: HCUP all-payer discharges (1/1/2016-12/31/2016) for AZ, FL, KY, MD, ME, MN, NE, NV, WA, processed with AHRQ v2019 software.*

*Notes: Race set to WHITE for all encounters for Nebraska and Maine as no RACE provided in STATE SID data. Derived AGE for Maine as “agegroup” is reported instead of AGE.*

*PSI 14A reflects postoperative wound dehiscence with an open approach and PSI 14B reflects non-open approach.*

*Abbreviations: SD=standard deviation; API=Asian or Pacific Islander*

**Table 3C. Descriptive Characteristics of Patients Included in Testing and Analysis, by PSI 90 Component Indicator, HCUP SID Population (2017) from 9 States**

| **PSI** | **Male (%)** | **Female (%)** | **Mean**  **age** | **Median**  **age** | **Age (SD)** | **White (%)** | **Black (%)** | **Hispanic (%)** | **API (%)** | **Native Amer (%)** | **Other (%)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PSI 03 | 49.0 | 51.0 | 63.4 | 66.0 | 18.4 | 71.8 | 12.7 | 9.5 | 1.4 | 0.7 | 4.0 |
| PSI 06 | 49.0 | 51.0 | 62.0 | 64.0 | 18.5 | 71.6 | 12.7 | 9.8 | 1.4 | 0.7 | 3.9 |
| PSI 08 | 48.5 | 51.5 | 63.1 | 65.0 | 17.8 | 72.0 | 12.5 | 9.7 | 1.4 | 0.7 | 3.7 |
| PSI 09 | 48.6 | 51.5 | 62.1 | 64.0 | 15.9 | 75.0 | 9.2 | 9.2 | 1.3 | 0.6 | 4.7 |
| PSI 10 | 45.2 | 54.8 | 62.8 | 65.0 | 14.0 | 78.7 | 7.7 | 6.4 | 1.2 | 0.4 | 5.6 |
| PSI 11 | 42.5 | 57.5 | 61.8 | 64.0 | 14.0 | 78.5 | 8.0 | 6.5 | 1.2 | 0.4 | 5.4 |
| PSI 12 | 49.2 | 50.9 | 62.3 | 64.0 | 15.9 | 74.9 | 9.2 | 9.2 | 1.4 | 0.6 | 4.7 |
| PSI 13 | 45.2 | 54.8 | 62.9 | 65.0 | 14.0 | 78.5 | 7.8 | 6.4 | 1.3 | 0.4 | 5.6 |
| PSI 14A | 43.5 | 56.5 | 59.9 | 61.0 | 15.9 | 71.6 | 11.2 | 9.6 | 1.6 | 0.5 | 5.6 |
| PSI 14B | 46.0 | 54.0 | 58.0 | 59.0 | 17.0 | 69.1 | 10.3 | 13.6 | 1.8 | 0.7 | 4.4 |
| PSI 15 | 48.1 | 51.9 | 60.9 | 63.0 | 17.1 | 70.3 | 11.7 | 11.2 | 1.7 | 0.7 | 4.5 |

*Source: HCUP all-payer discharges (1/1/2017-12/31/2017) for AZ, FL, KY, MD, ME, MN, NE, NV, WA, processed with AHRQ v2019 software.*

*Notes: Race set to WHITE for all encounters for Nebraska and Maine as no RACE provided in STATE SID data. Derived AGE for Maine as “agegroup” is reported instead of AGE.*

*PSI 14A reflects postoperative wound dehiscence with an open approach and PSI 14B reflects non-open approach.*

*Abbreviations: SD=standard deviation; API=Asian or Pacific Islander*

# If there are differences in the data or sample used for different aspects of testing (e.g., reliability, validity, exclusions, risk adjustment), identify how the data or sample are different for each aspect of testing reported below.

The data sets described above were used for all aspects of testing.

**1.8 What were the social risk factors that were available and analyzed?** For example, patient-reported data (e.g., income, education, language), proxy variables when social risk data are not collected from each patient (e.g. census tract), or patient community characteristics (e.g. percent vacant housing, crime rate) which do not have to be a proxy for patient-level data.

We analyzed PSI 90 rates among dual-eligible (Medicaid plus Medicare) beneficiaries and racial/ethnic minority beneficiaries. The FFS data do not include other relevant information at the individual level. In addition, we categorized hospitals by the percentage of dual-eligible patients and the percentage of minority patients among all of their Medicare FFS admissions. We do not currently have access to 9-digit zip code data necessary for geocoding to census tracts. We do not have patient-reported data.

# 2a2. RELIABILITY TESTING

***Note****: If accuracy/correctness (validity) of data elements was empirically tested*, *separate reliability testing of data elements is not required – in 2a2.1 check critical data elements; in 2a2.2 enter “see section 2b2 for validity testing of data elements”; and skip 2a2.3 and 2a2.4.*

**2a2.1. What level of reliability testing was conducted**? (*may be one or both levels*)

***Note****: Current guidance for composite measure evaluation states that reliability must be demonstrated for the composite performance measure score.*

**Performance measure score** (e.g., *signal-to-noise analysis*)

**2a2.2. Describe the method of reliability testing and what it tests** (*describe the steps―do not just name a method; what type of error does it test; what statistical analysis was used*)

**Component Reliability:** For component PSIs, we calculated measure reliability using estimated intraclass correlation coefficients (ICC), a type of signal-to-noise analysis.*[[4]](#footnote-5)* Signal-to-noise analysis seeks to distinguish the true variation in measure scores across providers (signal) from measurement error (noise). For each hospital, reliability (also known as the signal-to-noise ratio) is defined as:

Formula: Reliability is defined as the signal variance divided by the sum of the signal and noise variance

We define noise variance and signal variance as follows:

* **Noise variance**: the conditional variance of a measure (in this case, the observed hospital-level risk-adjusted rate), given the true risk-adjusted hospital rate, where the conditional variance is due to sampling error within each hospital.
* **Signal variance:** the between-hospital variance in the true value of the measures (that is, variation due to hospital performance).

We calculated the noise variance for each PSI 90 component as the sampling variance of the risk-adjusted rates, assuming each discharge follows a Bernoulli distribution, with the probability of an adverse event being estimated from the population risk-adjustment model. The calculation of the signal variance for each component measure assumes the following implicit two-stage model:

* Stage 1: True risk-adjusted hospital rates are distributed approximately normal (reference population rate, signal variance)
* Stage 2: Sampled risk-adjusted hospital rates, given true risk-adjusted hospital rates, are distributed approximately normal (true risk-adjusted hospital rate, noise variance)

To estimate the signal variance, we implemented an estimation procedure similar to the method proposed by Carl Morris.[[5]](#footnote-6) We used an iterative algorithm because the noise variance for different hospitals varies substantially. The same iterative method is used in CMS v10.0 software to calculate smoothed PSI rates.

#### **Composite Reliability:** The signal-to-noise reliability approach does not apply to PSI 90 as a composite measure, because PSI 90 is a weighted average of risk-adjusted, reliability-adjusted (smoothed) component measures. In other words, each hospital’s own signal-to-noise reliability is used as a shrinkage parameter to determine how far to shrink that hospital’s estimate toward the national reference mean of 1.0. Through this process, noise variance is essentially removed. Therefore, we apply split-half and test-retest approaches to estimate the reliability of smoothed measures such as PSI 90.

#### For hospital h in subsample t where each hospital subsample is based on summarizing performance across a varying number of denominator-eligible cases (nht) , we assumed that the smoothed and risk-adjusted performance measure for hospital h and subsample t (Yht) follows a simple two-level model: The smoothed risk-adjusted performance measure for hospital h and subsample t is equal to the mean value of the performance measure plus hospital effects plus residual errors

#### where the hospital effects (αh) are sampled from a normal distribution with mean 0 and variance of hospital effects (σb2) and the residual errors ( εht) are independently sampled from a normal distribution with mean 0 and variance: The ratio of the variance of error terms over the number of denominator cases from that hospital in that subsample

The subsamples here could come from different calendar periods or from randomly generated subsamples (e.g. split-halves) of patients, stratified by hospital. In the split-half approach, we set T=2 without replacement, resulting in two records per hospital based on all-inclusive and mutually exclusive subsamples. In the test-retest approach, we “tested” using the publicly reported v10 data period, 7/1/2016-6/30/2018, and “retested” using the subsequent year of non-overlapping data. Note that the specification of the residual error variance assumes that, conditional on hospital random effects, the variance is inversely proportional to the sample size used to form the hospital-subsample estimate.

We used SAS PROC NLMIXED to analyze the dataset where the units of analysis are hospital subsample estimates. This allowed us to specify a two-level random effects model (hospital subsamples nested within hospital) to properly account for the between-observation variation in denominator sizes, so that we could obtain maximum likelihood estimates of the variance components, including the between hospital variance component (σb2 )and the the error variance component (σe2). These estimates were then used in a “plug-in” estimator of the classical intracluster correlation coefficient (ICC):   
To properly account for the between-observation variation in denominator sizes so that we would obtain maximum likelihood estimates of between hospital variance components and error variance components we calculated the classical intracluster correlation coeffieicent or ICC,

where R equals the ratio of the between hospital variance component to the error variance component,which is the ratio of the the between-hospital variance component (σb2)over the error variance component (σe2), and n is a hospital’s denominator-eligible sample size.

Weighted averaging of multiple component PSIs (each of which is separately risk-adjusted and reliability-adjusted) helps to ensure the validity of the distributional assumption for PSI 90. By design, hospital-level PSI 90 values are centered around 1 with an approximately normal distribution (allowing for the fact that the tails of the distribution may be augmented with hospitals that are true quality outliers).[[6]](#footnote-7) Because this ICC depends only on the ratio of between-hospital to within-hospital estimated variance components, and the number of denominator-eligible cases at each hospital, we can estimate reliability as a function of the hospital’s subsample size, using an application of the Spearman-Brown prophecy formula.[[7]](#footnote-8) We applied this methodology to hospital subsamples that were formed by randomly dividing the two years of patient data in the current v10 reporting period (July 1, 2016 through June 30, 2018)[[8]](#footnote-9) from each hospital into two, then executing the PSI software separately on each split-half, to yield two estimates per hospital. We repeated this exercise after adding a subsequent year of data (July 1, 2018 through June 30, 2019) to assess test-retest reliability.

**2a2.3. What were the statistical results from reliability testing**? (e*.g., percent agreement and kappa for the critical data elements; distribution of reliability statistics from a signal-to-noise analysis*)

**Component Reliability:**

**Table 4. Weighted Mean Signal-to-Noise Reliability for PSI 90 Component Measures across Hospitals in Medicare Fee-for-Service Data, 2016-2018 (Comparing Current CMS v10.0 with Previous CMS v9.0)**

| **PSIs** | **CMS v10.0 signal-to-noise reliability**  **(N)** | **CMS v10.0 signal-to-noise reliability**  **(Weighted mean)** | **CMS v9.0 signal-to-noise reliability**  **(Weighted mean)** |
| --- | --- | --- | --- |
| PSI 03 | 3,294 | 0.777 | 0.784 |
| PSI 06 | 3,305 | 0.400 | 0.388 |
| PSI 08 | 3,303 | 0.152 | 0.208 |
| PSI 09 | 3,130 | 0.469 | 0.485 |
| PSI 10 | 3,008 | 0.489 | 0.509 |
| PSI 11 | 2,998 | 0.652 | 0.654 |
| PSI 12 | 3,131 | 0.610 | 0.609 |
| PSI 13 | 2,994 | 0.554 | 0.567 |
| PSI 14 | 3,060 | 0.167 | 0.261 |
| PSI 15 | 3,152 | 0.443 | 0.443 |

*Source: CMS v10.0 findings were generated by UC Davis through analysis of Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018). CMS v9.0 represents analysis of Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) through CMS v9.0, reported in the CVP/Mathematica Scientific Acceptability Report, December 2019.*

*These reliability estimates are based on risk-adjusted measures; after smoothing or shrinkage, reliability estimates exceed 0.99.*

**Table 5. Distribution of Signal-to-Noise Reliability for PSI 90 Component Measures across Hospitals in Medicare Fee-for-Service Data, 2016-2018 (Using Current CMS v10.0)**

| **PSIs** | **Median**  **(50th percentile)** | **25th percentile** | **75th percentile** | **% Hospitals ≥0.4** |
| --- | --- | --- | --- | --- |
| PSI 03 | 0.668 | 0.347 | 0.829 | 71.3 |
| PSI 06 | 0.132 | 0.039 | 0.283 | 11.6 |
| PSI 08 | 0.036 | 0.012 | 0.077 | 0.03 |
| PSI 09 | 0.113 | 0.035 | 0.288 | 13.4 |
| PSI 10 | 0.079 | 0.024 | 0.241 | 11.5 |
| PSI 11 | 0.39 | 0.180 | 0.616 | 44.3 |
| PSI 12 | 0.341 | 0.153 | 0.564 | 41.1 |
| PSI 13 | 0.178 | 0.063 | 0.387 | 21.6 |
| PSI 14 | 0.026 | 0.010 | 0.059 | 0.1 |
| PSI 15 | 0.148 | 0.054 | 0.297 | 13.0 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with CMS v10.0 software.*

*These reliability estimates are based on risk-adjusted measures; after smoothing or shrinkage, reliability estimates exceed 0.99.*

**Composite Reliability:**

**Table 6. Split Sample PSI 90 Reliability at Hospital Level in Medicare Fee-for-Service Data, 2016-2018**

| **Reliability Assessment** | **24 months of data** | **36 months of data** |
| --- | --- | --- |
| Hospitals meeting 3 case minimum | 3,305 | 3,305 |
| Median Intracluster Correlation Coefficient (ICC) | 0.74 | 0.81 |
| % Hospitals meeting ICC>0.6 | 67% | 76% |
| % Hospitals meeting ICC>0.4 | 83% | 89% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with CMS v10.0 software.*

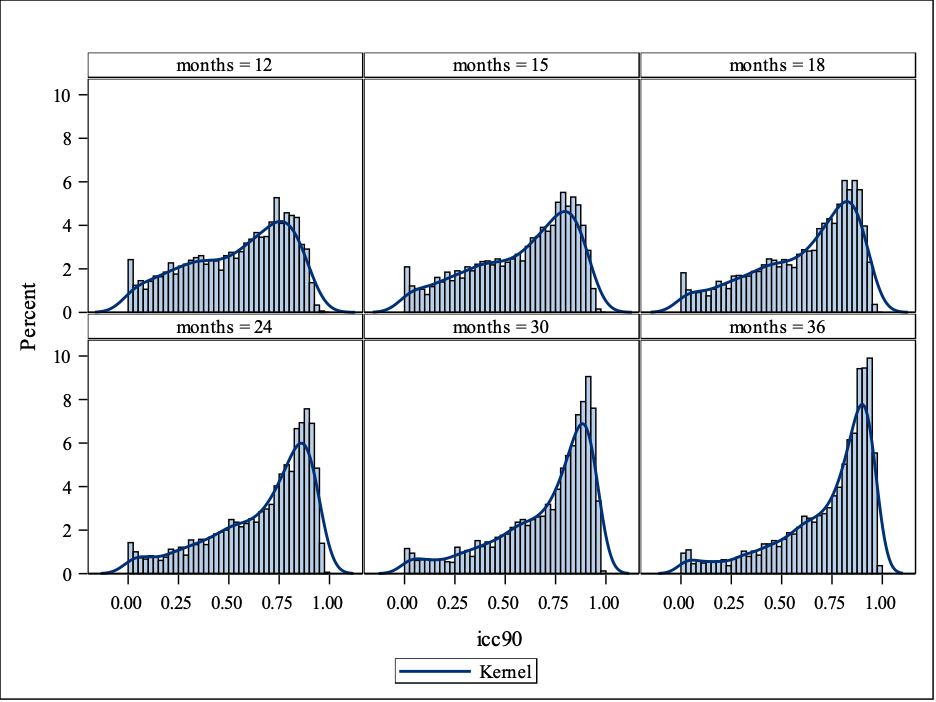
**Table 7. Test-Retest PSI 90 Consistency at Hospital Level in Medicare Fee-for-Service Data, 2016-2019**

| **Reliability Assessment** | **24 months of data** | **36 months of data** |
| --- | --- | --- |
| Hospitals meeting 3 case minimum | 3,305 | 3,305 |
| Median Intracluster Correlation Coefficient (ICC) | 0.61 | 0.70 |
| % Hospitals meeting ICC>0.6 | 51% | 62% |
| % Hospitals meeting ICC>0.4 | 72% | 81% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with CMS v10.0 software.*

*In this analysis, the third year of data was “held out” to assess test-retest reliability.*

**Figure 1. Distribution of Split Sample Intracluster Correlation Coefficients for PSI 90 by Duration of Data Collection Period (Percentage of hospitals is shown on y axis)**



*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with CMS v10.0 software.*

**Table 8. Test-Retest PSI 90 Consistency at Hospital Level in All-Payer State Inpatient Data (2016-2017), Using 12 Months of Data to Estimate ICC (C,1)**

| **State** | **# Hospitals** | **Overall ICC** | **95% CI,**  **Lower Bound** | **95% CI,**  **Upper Bound** |
| --- | --- | --- | --- | --- |
| 9 States Combined | 900 | 0.746 | 0.716 | 0.774 |

*Source: HCUP inpatient discharge data from (1/1/2016-12/31/2017) processed with AHRQ v2019 software.*

*Abbreviations: CI=confidence interval; ICC=intracluster correlation coefficient*

**2a2.4 What is your interpretation of the results in terms of demonstrating reliability**? (i*.e., what do the results mean and what are the norms for the test conducted?*)

**Composite**: Reliability scores vary from 0 to 1, with a score of 0 indicating that all variation is attributable to measurement error whereas a score of 1 implies that all variation is caused by real differences in performance across accountable entities. As shown in **Table 6**, PSI 90 demonstrates moderate-to-high score reliability at the hospital level, with an overall split half (intracluster correlation coefficient, ICC) reliability estimate of 0.74 based on 24 months of Medicare FFS claims data, and 67% of facilities exceeding ICC=0.6. If even higher reliability were desired, the data period could be increased to 36 months, with split half reliability of 0.81 and 76% of facilities exceeding ICC=0.6 **(Table 6)**. As the reliability distribution in **Figure 1** shows, only 2-3% of hospitals have very low reliability (ICC<0.05). CMS anticipates excluding most of these low-reliability hospitals from public reporting using a minimum volume threshold (e.g., 25 denominator records) and a missing data threshold, as described further below.

An even more rigorous test of reliability at the hospital level is to use a holdout sample from a separate, subsequent time period, a concept known as test-retest reliability. In this approach, the within-hospital signal is diluted by changes over time, as hospitals invest in quality improvement activities and systematically improve their performance at different rates. As shown in **Table 7**, the current 24-month reporting period still meets the reliability standard for hospital-level reporting with a median test-retest ICC of 0.61.

We also analyzed test-retest consistency using all-payer data from several states (instead of two years of Medicare FFS claims data) because PSI 90 was originally submitted to NQF as an all-payer claims-based measure. As shown in **Table 8**, these test-retest ICCs between test year 2016 and retest year 2017 varied across states but averaged to 0.746 (95% confidence interval, 0.716-0.774). This value is almost identical to that provided in AHRQ’s 2015 submission for this measure (ICC=0.76), showing that score-level reliability has been consistent over time.

**Components**: As shown in **Tables 4 and 5**, signal-to-noise reliability varies across the PSI 90 component measures, with more frequent events (i.e., PSI 03, PSI 11, PSI 12, PSI 13) having higher signal-to-noise reliability (weighted mean >0.5) than rare events (i.e., PSI 08, PSI 14, with weighted mean <0.3). Among all the PSI 90 component measures, only PSI 03 would definitively meet a conventional threshold for public reporting (e.g., median >0.6 in **Table 5**, weighted mean >0.7 in **Table 4**) as a standalone measure using 24 months of Medicare FFS claims data, which highlights the importance of PSI 90 as a composite measure that draws statistical strength from all of its component measures.

# 2b1. VALIDITY TESTING

***Note****: Current guidance for composite measure evaluation states that validity should be demonstrated for the composite performance measure score. If not feasible for initial endorsement, acceptable alternatives include assessment of content or face validity of the composite OR demonstration of validity for each component. Empirical validity testing of the composite measure score is expected by the time of endorsement maintenance.*

# 2b1.1. What level of validity testing was conducted?

* **Critical data elements** (*data element validity must address ALL critical data elements*)

# Composite performance measure score

**Empirical validity testing**

**Systematic assessment of face validity of performance measure score as an indicator** of quality

or resource use (*i.e., is an accurate reflection of performance on quality or resource use and can distinguish good from poor performance*) **NOTE**: Empirical validity testing is expected at time of maintenance review; if not possible, justification is required.

**Validity testing for component measures** *(check all that apply)*

***Note****: applies to ALL component measures, unless already endorsed or are being submitted for individual endorsement.*

# Endorsed (or submitted) as individual performance measures

* + **Critical data elements** (*data element validity must address ALL critical data elements*)

# Empirical validity testing of the component measure score(s)

# Systematic assessment of face validity of component measure score(s) as an indicator of quality

or resource use (*i.e., is an accurate reflection of performance on quality or resource use and can distinguish good from poor performance*)

**2b1.2. For each level of testing checked above, describe the method of validity testing and what it tests** (*describe the steps―do not just name a method; what was tested, e.g., accuracy of data elements compared to authoritative source, relationship to another measure as expected; what statistical analysis was used)*

**Face validity** refers to the degree to which evidence, clinical judgment, and theory support the interpretations of a measure score. Face validity is an assessment by experts that determines the extent to which a measure, at face value, appears to reflect what it is intended to assess.

In 2014-15, a standing workgroup of clinicians with experience relevant to the PSI90 composite and its component indicators was convened to review the measure and provide guidance regarding indicator refinements. Standing workgroup members were solicited via Federal Register notices to ensure that interested parties were allowed equal opportunity for participation. Members could be nominated or self-nominated. Nominees were selected by a stringent rating system that measured each nominee’s quality measurement knowledge, quality improvement experience, clinical expertise, written publications related to the use and application of the AHRQ QIs and their knowledge of the NQF measure endorsement process. Workgroup members selected for participation were familiar with the routine updates and maintenance of the AHRQ QIs, relevant literature pertaining to potential enhancements of the AHRQ QIs, methodological changes and refinements, application to the software refinements, and AHRQ QI user needs. Panel composition was designed to ensure a wide variety of quality indicator knowledge and experience.

In 2019, CMS convened a new Technical Expert Panel, following standard processes outlined in the CMS Measures Management System Blueprint,[[9]](#footnote-10) to advise the measure developer on updated specifications and scientific acceptability testing for PSI 90, and to assess the results of this testing. To determine face validity, we obtained input from members of this TEP to determine whether they think the measure as specified will help inform consumers and help providers improve quality. On July 20, 2020, TEP members voted 12-1 in favor of contined use of PSI 90, subject to reassessment as additional validation data and measures become available.

**Component Validity:** Predictive validity is a type of construct validity that focuses on a measure’s ability to predict subsequent outcomes of well-established validity and clinical importance. In this case, we assessed predictive validity based on the estimated marginal effect of each PSI 90 component event on subsequent harms in the Medicare FFS population, after adjusting for the propensity of that PSI (and the occurrence of other PSIs that could contribute to causing the same outcomes). These subsequent harms include:

* Death at hospital discharge, and within 30 and 180 days after discharge (the longer time window was used for PSIs 03, 10, 11, 12, 13, and 14 based on expert input confirmed by empirical analysis of post-event survival curves)
* Readmission to an acute care hospital within 30 days after discharge (and inpatient days during that time window)
* Transfer to long-term acute, inpatient rehabilitation, or post-acute skilled nursing care (and inpatient days in that setting)
* Admission to long-term skilled nursing care (and days in that setting)
* Chronic dialysis (for PSI 10)
* Late complications such as tracheostomy to support long-term mechanical ventilation (PSI 11), osteomyelitis and other deep soft tissue infections (PSI 03), anoxic brain injury or other shock-related complications (PSI 09), extension of thrombosis or anticoagulant-related bleeding (PSI 12), enterocutaneous fistula or incisional hernia (PSI 14), and abscess or fistula (PSI 15).

We calculated excess harm risks for each PSI 90 component using CMS datasets: the Research Identifiable Files (RIF) and the Medicare Master Beneficiary Summary Files (MBSF). These files were used to estimate the average excess number of harmful outcomes associated with each component PSI using a separate cohort for each indicator based on denominator-eligible records. Index hospitalizations with the PSI (numerator event) were compared with eligible hospitalizations without the PSI event. To account for potential confounding between the risk factors for developing a PSI and the risk factors for developing the harms independent of the PSI, we weighted observations by the inverse probability of treatment to estimate the “average treatment effect in the treated” for those with the PSI event. We then fit separate regression models for each harm outcome: probability models for binary outcomes and linear models for length of stay.

**Composite Validity:** Construct validity refers to the extent to which the measure generates estimates that are consistent with a construct or conceptual framework regarding how safe care is produced and defined. For example, convergent validity refers to whether multiple measures of an underlying concept are positively correlated with each other. To assess the convergent validity of the PSIs, we compared PSI results with related measures of patient safety and outcomes at the hospital level, publicly available on [https://data.Medicare.gov](https://data.medicare.gov/). Using Spearman rank correlation coefficients, we compared hospital-level PSI rates with rates of complications for hip/knee replacement patients, risk-standardized 30-day readmission rates (e.g., hospital-wide unplanned all-cause readmissions) and health care-associated infection measures from the National Healthcare Safety Network (central line associated bloodstream infection, Clostridium difficele infection, catheter-associated urinary tract infection, surgical site infection, and methicillin-resistant Staphylococcus aureus). Correlations among these measures would support the validity of the PSIs because they measure a similar quality construct of patient safety. However, we do not expect strong correlations because patient safety is a complex construct, and these measures differ from the PSIs in terms of the populations and conditions being measured.

We further assessed convergent validity using the results of the Leapfrog Group’s Hospital Safety Survey, which is used (in combination with PSI 90 and other measures) to assign Hospital Safety Grades. A key advantage of this latter data source is that hospital respondents are audited and asked to provide documentation to support the accuracy of their survey responses. We hypothesized that hospitals with greater implementation of safe practices woiuld have lower PSI 90 rates than hospitals with less implementation of safe practices.

Known groups validity is a final type of construct validity that focuses on a measure’s ability to discriminate between groups of measured entities that are known to differ on the underlying latent construct. With respect to hospital quality and safety, prior research has demonstrated several “known groups” that can be identified from the available data:

* Hospital resident-to-bed ratio, stratified as major teaching/academic (at least 0.25 full-time equivalent [FTE] residents per bed), minor teaching/academic (more than 0 but less than 0.25 FTE residents per bed), and non-teaching.
* Hospital nurse-to-bed ratio, stratified as highly staffed (more than 2.0 FTE licensed nurses per bed), moderately staffed (1.0-2.0 nurses per bed), poorly staffed (less than 1.0 nurses per bed).
* Hospital nurse skill mix, estimated as the proportion of all nursing FTEs or nursing hours that are provided by registered nurses (versus licensed vocational/practical nurses), stratified as relatively low (less than 85%), medium (85-97.5%), and high (over 97.5%).

We hypothesized that PSI 90 rates (reflecting risk-adjustment) would be equivalent or lower at teaching hospitals and at hospitals with high nurse staffing and skill mix than at non-teaching hospitals and hospitals with low nurse staffing and skill mix, respectively.

**2b1.3. What were the statistical results from validity testing**? (*e.g., correlation; t-test*)

**Component Validity:**

**Table 9. Predictive Validity of PSI 90 Components at the Patient Level, Showing the Average Marginal Effect of Each PSI Event on Subsequent Adverse Outcomes (after Adjusting for Confounding Factors through Inverse Probability Propensity Weighting)**

| **Adverse Outcome (absolute diff in days or %)** | **PSI 03** | **PSI 06** | **PSI 08** | **PSI 09** | **PSI 10** | **PSI 11** | **PSI 12** | **PSI 13** | **PSI 14** | **PSI 15** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hospital Length of Stay (days) | 9.3 | 4.6 | 4.5 | 5.1 | 11.4 | 7.1 | 8.0 | 12.0 | 12.2 | 14.2 |
| 30-day readmission | 5.0% | 0.0% | 9.1% | 4.7% | 6.3% | 5.2% | 5.8% | 4.8% | 8.4% | 7.3% |
| Death  (30\*/180 days) | 27.0% | 13.0%\* | 7.3%\* | 4.5%\* | 32.7% | 18.6% | 13.4% | 28.6% | 10.8% | 10.1%\* |
| Long-term SNF admission | 9.3% | 0.0% | 25.3% | 3.1% | 2.9% | 6.3% | 5.0% | 6.5% | 10.2% | 5.4% |
| SNF Length of Stay (days) | 8.8 | 0 | 18.6 | 2.5 | 1.8 | 4.7 | 3.9 | 4.9 | 8.2 | 4.8 |
| Late complication\*\* | 7.4% | N/A | N/A | 10.7% | N/A | N/A | N/A | N/A | 1.7% | 9.4% |
| Late operation\*\*\* | 4.9% | N/A | 0.12% | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Late incisional hernia | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 1.4% | N/A |
| Tracheostomy | N/A | N/A | N/A | N/A | N/A | 14.0% | N/A | N/A | N/A | N/A |
| DVT/PE/bleed  (ED visit) | N/A | N/A | N/A | N/A | N/A | N/A | 47.6% | N/A | N/A | N/A |
| Long-term dialysis | N/A | N/A | N/A | N/A | 4.3% | N/A | N/A | N/A | N/A | N/A |

*Source: CMS Inpatient and Outpatient Medicare Fee-For-Service data in the 100% standard analytical files (SAF).*

*Note: A separate cohort sample was drawn for each component PSI that was defined by that PSI's denominator criteria among inpatient stays in CY 2012. Data from CY 2013 were used for follow-up only, to ensure that a full 365 days of follow-up were available for each observation. Marginal effects were estimated using “average treatment effect in the treated” inverse propensity score weighting based on log odds of expected value from risk-adjustment models (0.72<c<0.91), with addition of sociodemographic factors and co-occurring PSIs, to account for confounding and alternate pathways to the same harm state.*

*N/A indicates harms that are not relevant to a particular component PSI measure.*

*\* indicates 30-day death*

*\*\* Late complications include osteomyelitis and other deep soft tissue infections for PSI 03 (Pressure Ulcer), anoxic brain injury or other shock-related complications for PSI 09 (Postoperative Hemorrhage or Hematoma), enterocutaneous fistula for PSI 14 (Postoperative Wound Dehiscence), and abscess or fistula for PSI 15 (Unrecognized Abdominopelvic Accidental Puncture/Laceration).*

*\*\* Late operations include flap and graft procedures for PSI 03 (Pressure Ulcer) and reoperations to treat complications of the original repair for PSI 08 (In-hospital Fall with Hip Fracture).*

*Abbreviations: DVT=deep vein thrombosis; ED=emergency department; PE=pulmonary embolism; SNF=skilled nursing facility*

**Composite Validity:**

**Table 10. Convergent Validity Between PSI 90 and Infection-Related Outcome Measures by Spearman Rank Correlation, Using Different Data Periods**

| **Hospital Compare Measures** | **Hospitals** | **PSI 90 – CMS v10, 2016-2018** | **PSI 90 – CMS v10, 2017-2019** |
| --- | --- | --- | --- |
| Hip/knee complication rate | 2,387 | 0.149\*\*\* | 0.136\*\*\* |
| Central line-associated bloodstream infection (CLABSI) | 2,273 | 0.042\* | 0.040 |
| Catheter-associated urinary tract infection | 2,536 | 0.047\* | 0.060\*\* |
| Clostridium difficile (C. diff) infection | 2,946 | 0.054\*\* | 0.060\*\* |
| Surgical-site infection (SSI) following abdominal hysterectomy/colon procedure | 2,425 | 0.108\*\*\* | 0.104\*\*\* |
| Methicillin-resistant Staphylococcus aureus (MRSA) bacteremia | 2,131 | 0.058\* | 0.072\*\* |
| Total healthcare-acquired condition (HAC) score | 3,188 | 0.420\*\*\* | 0.347\*\*\* |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with v10.0 CMS software.*

*Other measure results retrieved from Hospital Compare data on https://data.medicare.gov/ which was updated on 10/30/2019, including infection data from 1/1/2017-12/31/2018*

*\* p<0.05, \*\* p<0.005, \*\*\* p<0.0005*

**Table 11. Convergent Validity Between PSI 90 and 30-day Readmission Measures by Spearman Rank Correlation, Using Different Data Periods**

| **Hospital Compare Measures** | **Hospitals** | **PSI 90 – CMS v10, 2016-2018** | **PSI 90 – CMS v10, 2017-2019** |
| --- | --- | --- | --- |
| 30-day readmission: Acute Myocardial Infarction (AMI) | 2,061 | 0.024 | 0.016 |
| 30-day readmission: Coronary Artery Bypass Graft (CABG) | 994 | 0.058 | 0.054 |
| 30-day readmission: Chronic Obstructive Pulmonary Disease (COPD) | 2,836 | 0.037\* | 0.043\* |
| 30-day readmission: Heart Failure | 2,856 | 0.059\*\* | 0.045\* |
| 30-day readmission: Hip and Knee | 2,460 | 0.084\*\*\* | 0.096\*\*\* |
| 30-day readmission: Pneumonia | 2,927 | 0.065\*\*\* | 0.070\*\*\* |
| 30-day readmission: Hospital-wide | 3,140 | 0.138\*\*\* | 0.145\*\*\* |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with v10.0 CMS software.*

*Other measure results retrieved from Hospital Compare data on https://data.medicare.gov/ which was updated on 10/30/2019, including readmission data from 7/1/2015-6/30/2018.*

*\* p<0.05, \*\* p<0.005, \*\*\* p<0.0005*

**Table 12. Convergent Validity Between PSI 90 and Leapfrog Survey Safe Practice Scores, Based on Mean PSI 90 Values by Category of Response**

| **Safe Practice Score: Overall Performance** | **Hospitals (%)** | **Mean Score (SD)** | **Relative risk (compared with “fully meets standard”)** |
| --- | --- | --- | --- |
| Fully meets standard | 1,493 (49.2%) | 1.002 (0.215) | 1 |
| Substantial progress | 183 (6.0%) | 0.983 (0.179) | 0.981 |
| Some progress | 45 (1.5%) | 1.009 (0.193) | 1.007 |
| Willing to report | 38 (1.3%) | 1.033 (0.192) | 1.031 |
| Declined to respond | 1,274 (42.0%) | 0.986 (0.174) | 0.984 |

*Source: 2019 (v8.0) Leapfrog Hospital Survey linked with Medicare FFS discharges from IPPS hospitals (7/1/2017-6/30/2019) processed with v10.0 CMS software.*

*Abbreviation: SD=standard deviation*

**Table 13. Convergent Validity Between PSI 90 and Leapfrog Survey Safe Practice Scores by Spearman Rank Correlation, Excluding Hospitals that Declined to Respond**

| **Performance on Safe Practice Measures** | **Hospitals** | **Mean Score (SD)** | **PSI 90 – CMS v10, 2017-2019** |
| --- | --- | --- | --- |
| Culture of safety leadership structures and systems (out of 120 points) | 1,759 | 116.92 (8.46) | 0.034 |
| Culture measurement, feedback and interventions (out of 120 points) | 1,759 | 116.47 (12.95) | -0.020 |
| Risks and hazards (out of 100 points) | 1,759 | 97.25 (9.63) | -0.017 |
| Nursing workforce (out of 100 points) | 1,759 | 97.60 (9.09) | -0.021 |
| Hand hygiene (out of 60 points) | 1,759 | 57.22 (7.93) | -0.017 |

*Source: 2019 (v8.0) Leapfrog Hospital Survey linked with Medicare FFS discharges from IPPS hospitals (7/1/2017-6/30/2019) processed with v10.0 CMS software.*

*Abbreviation: SD=standard deviation*

**Table 14. Known Groups Validity for PSI 90**

| **Known Groups Category** | **Hospitals (%)** | **Mean** | **SD** |
| --- | --- | --- | --- |
| **Hospital Teaching** | **--** | **--** | **--** |
| Resident FTE/bed ratio = 0 | 2,564 (79.3%) | 0.978 | 0.168 |
| Resident FTE/bed ratio (0 - 0.25) | 471 (14.6%) | 1.013 | 0.194 |
| Resident FTE/bed ratio >0.25 | 196 (6.1%) | 1.125 | 0.372 |
| **Hospital Nursing\*** | **--** | **--** | **--** |
| Nurse FTE/bed ratio <1.0 | 950 (29.4%) | 0.985 | 0.154 |
| Nurse FTE/bed ratio (1.0 – 2.0) | 1,700 (52.6%) | 0.995 | 0.188 |
| Nurse FTE/bed ratio >2.0 | 581 (18.0%) | 0.992 | 0.258 |
| **Nursing Skill Mix\*\*** | **--** | **--** | **--** |
| Low (<0.85) | 765 (23.7%) | 0.995 | 0.175 |
| Medium (0.85-0.975) | 1,359 (42.0%) | 1.002 | 0.218 |
| High (>0.975) | 1,107 (34.3%) | 0.976 | 0.172 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviation: FTE=full-time equivalent; SD=standard deviation*

*\* Spearman rank correlation between nurse FTE/bed ratio and CMS Medicare PSI 90 is -0.042 (p<0.05).*

*\*\* Spearman rank correlation between nursing skill mix percentage and CMS Medicare PSI 90 is -0.071 (p<0.0001)*

**2b1.4. What is your interpretation of the results in terms of demonstrating validity**? (i*.e., what do the results mean and what are the norms for the test conducted?*)

We assessed each component measure individually to determine whether it was valid to include in the composite measure by calculating the average marginal effects, or absolute difference in event rates, between balanced groups with and without the PSI. We used inverse propensity score weighting to balance the PSI-exposed and unexposed groups on measured characteristics, including all features in the corresponding risk-adjustment model and additional social risk factors (e.g., dual eligibility, race/ethnicity). As shown in **Table 9** above, all component events were independently predictive of hospital length of stay and 30-180 day mortality. For example, the average patient who experienced a stage 3, 4, or unstageable pressure injury (PSI 03) spent an extra 9.3 days in the hospital, and had a 27% higher absolute risk of death within 180 days, than an otherwise identical patient who did not experience PSI 03. All events except for iatrogenic pneumothorax (PSI 06) were also independently predictive of hospital readmissions and nursing home admissions. For example, the average patient who experienced PSI 03 spent an extra 8.8 days in post-acute skilled nursing care, and had a 5.0% higher absolute risk of readmission within 30 days and a 9.3% higher absolute risk of long-term nursing home placement, than an otherwise identical patient who did not experience PSI 03. These findings strongly support the predictive validity of PSI 90 and its components at the patient level.

Construct validity for PSI 90 at the hospital level is moderate. PSI 90 correlates satisfactorily with other, independently collected, NQF-endorsed measures of hospital harms, including hospital-acquired infection standardized morbidity ratios (**Table 10**) and 30-day risk-standardized readmission rates (**Table 11**). Given that PSI 90 is dominated by perioperative and postoperative complications, it is not surprising that these correlations are higher for surgical patients (e.g., surgical site infection rates and hip/knee complication rates in **Table 10**) than for medical patients. As shown in **Table 11**, rank correlations between PSI 90 and hospital-wide readmission rates are especially high at 0.138–0.145 (p<0.0001). (In previous NQF endorsement review, a very similar correlation of 0.11 (p<0.0001) was reported with the Potentially Preventable Readmission Rate, based on a methodology developed by 3M Health Information Systems.) Although these correlations may seem low, they are consistent across all comparisons and they reflect the fact that each type of hospital performance measure contributes unique information.

To explore process-outcome relationships, we assessed hospital-level correlations between PSI 90 and implementation of evidence-based safe practices, as reported by hospitals in the annual survey conducted by the Leapfrog Group. **Table 12** shows that the 38 hospitals that responded to the Leapfrog survey but reported little progress in implementing Safe Practices performed 3.3% worse on PSI 90, on average, than the 1,676 hospitals that reported full or nearly full implementation, while the 45 hospitals that reported “some” progress performed 0.9% worse. **Table 13** confirms that hospitals that reported greater implementation of NQF-endorsed Safe Practices (with the exception of “Culture of Safety Leadership Structures and Systems”) had nonsignificantly lower PSI 90 scores than hospitals that reported less implementation, with rank correlations of -0.017 to -0.021. These analyses are limited by ceiling effects in the Leapfrog survey; for example, the “Culture of Safety Leadership” score has a mean value of nearly 117 of 120, and a standard deviation of less than 9 (**Table 13**).

Analyses of known groups validity support PSI 90 for nursing skill mix, which has been the most consistent nursing-related correlate of hospital outcomes in prior research (see Twigg DE, Kutzer Y, Jacob E, Seaman K. A quantitative systematic review of the association between nurse skill mix and nursing-sensitive patient outcomes in the acute care setting. *J Adv Nurs* 2019;75(12):3404-23; also Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K. Nurse-staffing levels and the quality of care in hospitals. *N Engl J Med* 2002;346(22):1715-22). As shown in **Table 14**, hospitals that rely almost entirely on registered nurses, with a skill mix ratio greater than 0.975, had at least 2% better performance on CMS Medicare PSI 90 than hospitals that rely more heavily on licensed practical or vocational nurses (i.e., mean PSI 90 score 0.976 versus 0.995-1.002). As summarized in footnotes to **Table 14**, rank correlations with PSI 90 scores were statistically significant for both nurse staffing ratios (r=-0.042, p<0.05) and skill mix (r=-0.071, p<0.0001). Expressed another way (not shown in tables), 28% and 43% of statistical outliers with low PSI 90 scores reported the highest levels of nurse staffing and skill mix, respectively, versus 23% and 31% of statistical outliers with high PSI 90 scores.

It may be surprising that teaching hospitals appear to perform worse on PSI 90 than non-teaching hospitals, given a robust literature on mortality measures showing the opposite relationship. However, PSI 90 is dominated by surgical complications for which trainees may have higher incidence than experienced practitioners. Higher standard deviations for teaching hospitals indicate substantial variation in performance within this subgroup of hospitals.

# 2b2. EXCLUSIONS ANALYSIS

***Note:*** *Applies to the composite performance measure, as well all component measures unless they are already endorsed or are being submitted for individual endorsement.*

**NA** ☐ **no exclusions — *skip to section*** [***2b4***](#_bookmark6)

**2b2.1. Describe the method of testing exclusions and what it tests** (*describe the steps―do not just name a method; what was tested, e.g., whether exclusions affect overall performance scores; what statistical analysis was used*)

For component indicators, the current exclusion criteria are intrinsically embedded into the logic of the indicator (in SAS), including all of the risk-adjustment models and other analyses presented here. With a few minor exceptions, all of these exclusions were present through both previous rounds of NQF endorsement. To test the impact of these exclusions, we removed them one at a time from the logic of each component indicator, and enumerated the marginal and relative (%) increase in the number of numerator and denominator records as a result (and the resulting impact of dropping each exclusion on the observed indicator rate). The composite indicator does not apply additional exclusion criteria beyond those that are part of the component indicator specifications.

**2b2.2. What were the statistical results from testing exclusions**? (*include overall number and percentage of individuals excluded, frequency distribution of exclusions across measured entities, and impact on performance measure scores*)

**Table 15a. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Pressure Ulcer (PSI 03)**

| **PSI 03** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 13,477,287 | - | 8,126 | - | 0.603 | - |
| Principal diagnosis of stage 3, 4 or unstageable PU | 13,944 | 0.1% | 117 | 1.4% | 0.611 | 1.3% |
| All diagnoses of stage 3, 4 or unstageable PU are present on admission | 254,575 | 1.9% | 254,575 | 3132.8% | 19.131 | 3072.9% |
| Severe burns (>20% BSA) | 784 | 0.0% | 11 | 0.1% | 0.604 | 0.1% |
| Exfoliative disorders of the skin (>20% BSA) | 91 | 0.0% | 0 | 0.0% | 0.603 | 0.0% |
| MDC 14 (obstetrics) | 19,818 | 0.1% | 1 | 0.0% | 0.602 | -0.1% |
| LOS <3 days | 5,036,196 | 37.4% | 73 | 0.9% | 0.443 | -26.5% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: PU – pressure ulcer; MDC – major diagnostic category; LOS – length of stay; BSA – body surface area*

**Table 15b. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Iatrogenic Pneunothorax (PSI 06)**

| **PSI 06** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 17,444,847 | - | 4,421 | - | 0.253 | - |
| Principal diagnosis of iatrogenic pneumothorax (or secondary diagnosis present on admission) | 4,887 | 0.0% | 1,571 | 35.5% | 0.343 | 35.5% |
| Chest trauma or pleural effusion or MDC 14 (obstetrics) | 690,998 | 4.0% | 4,057 | 91.8% | 0.467 | 84.5% |
| Thoracic surgery or lung, cardiac, or diaphragmatic procedure | 513,188 | 2.9% | 11,109 | 251.3% | 0.865 | 241.2% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category*

**Table 15c. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, In Hospital Fall with Hip Fracture (PSI 08)**

| **PSI 08** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 15,331,356 | - | 1,660 | - | 0.108 | - |
| Principal diagnosis of hip fracture | 19,262 | 0.1% | 5 | 0.3% | 0.108 | 0.2% |
| Secondary diagnosis of hip fracture present on admission | 14,425 | 0.1% | 14,425 | 869.0% | 1.048 | 868.1% |
| Principal diagnosis of seizure, syncope, stroke, coma, cardiac arrest, poisoning, trauma, delirium, psychosis, anoxic brain injury | 1,646,475 | 10.7% | 161 | 9.7% | 0.107 | -0.9% |
| Metastatic, lymphoid, or bone cancer | 1,061,048 | 6.9% | 133 | 8.0% | 0.109 | 1.0% |
| MDC 14 (obstetrics) | 33,360 | 0.2% | 0 | 0.0% | 0.108 | -0.2% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category*

**Table 15d. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Perioperative Hemorrhage or Hematoma (PSI 09)**

| **PSI 09** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 4,672,895 | - | 11,644 | - | 2.492 | - |
| Principal diagnosis of postprocedural hemorrhage or hematoma | 7,410 | 0.2% | 24 | 0.2% | 2.493 | 0.0% |
| Secondary diagnosis of postprocedural hemor­rhage or hematoma present on admission | 3,080 | 0.1% | 3,080 | 26.5% | 3.149 | 26.4% |
| Only OR procedure is for control of hemorrhage or hematoma | 84,581 | 1.8% | 1,031 | 8.9% | 2.664 | 6.9% |
| Control of hemorrhage or hematoma occurs before first OR procedure | 452 | 0.0% | 452 | 3.9% | 2.588 | 3.9% |
| MDC 14 (obstetrics) | 12,602 | 0.3% | 4 | 0.0% | 2.486 | -0.2% |
| Coagulation disorder | 318,445 | 6.8% | 5,165 | 44.4% | 3.368 | 35.1% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category; OR – operating room*

**Table 15e. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Postoperative Acute Kidney Injury Requiring Dialysis (PSI 10)**

| **PSI 10** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 2,601,337 | - | 3,529 | - | 1.357 | - |
| Principal diagnosis of acute kidney injury | 12,730 | 0.5% | 10 | 0.3% | 1.354 | -0.2% |
| Secondary diagnosis of acute kidney injury present on admission | 554 | 0.0% | 554 | 15.7% | 1.569 | 15.7% |
| Dialysis on or before date of first OR procedure | 17,923 | 0.7% | 194 | 5.5% | 1.421 | 4.8% |
| Dialysis access procedure on or before date of first OR procedure | 1,977 | 0.1% | 1 | 0.0% | 1.356 | 0.0% |
| Principal diagnosis of cardiac arrest or dysrhythmia, shock, or chronic kidney disease | 10,148 | 0.4% | 31 | 0.9% | 1.363 | 0.5% |
| Secondary diagnosis of cardiac arrest or dysrhythmia, shock, or chronic kidney disease on admission | 990 | 0.0% | 990 | 28.1% | 1.737 | 28.0% |
| Solitary kidney or S/P nephrectomy | 432 | 0.0% | 12 | 0.3% | 1.361 | 0.3% |
| MDC 14 (obstetrics) | 6,942 | 0.3% | 0 | 0.0% | 1.353 | -0.3% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category; OR – operating room; S/P – status post*

**Table 15f. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Postoperative Respiratory Failure (PSI 11)**

| **PSI 11** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 2,105,347 | - | 12,954 | - | 6.153 | - |
| Principal diagnosis of postprocedural respiratory failure | 0 | 0.0% | 0 | 0.0% | 6.153 | 0.0% |
| Secondary diagnosis of postprocedural respiratory failure present on admission | 1,297 | 0.1% | 1,297 | 10.0% | 6.765 | 9.9% |
| Tracheostomy is only OR procedure | 5 | 0.0% | 0 | 0.0% | 6.153 | 0.0% |
| Tracheostomy occurs before first OR procedure | 0 | 0.0% | 0 | 0.0% | 6.153 | 0.0% |
| Neuromuscular disorder | 6,518 | 0.3% | 239 | 1.8% | 6.247 | 1.5% |
| Laryngeal, pharyngeal, nose, mouth, facial surgery | 21,753 | 1.0% | 1,991 | 15.4% | 7.026 | 14.2% |
| Esophageal resection | 3,913 | 0.2% | 374 | 2.9% | 6.319 | 2.7% |
| Lung cancer | 806 | 0.0% | 31 | 0.2% | 6.165 | 0.2% |
| Degenerative neurologic disorder | 50,540 | 2.4% | 1,304 | 10.1% | 6.614 | 7.5% |
| Lung transplant | 9 | 0.0% | 1 | 0.0% | 6.153 | 0.0% |
| MDC 4 (respiratory), MDC 5 (circulatory), MDC 14 (obstetrics) | 401,708 | 19.1% | 11,996 | 92.6% | 9.952 | 61.7% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category; OR – operating room*

**Table 15g. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Perioperative Pulmonary Embolism or Deep Vein Thrombosis (PSI 12)**

| **PSI 12** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 4,996,379 | - | 18,788 | - | 3.760 | - |
| Principal diagnosis of DVT or PE | 3,562 | 0.1% | 39 | 0.2% | 3.765 | 0.1% |
| Secondary diagnosis of DVT or PE present on admission | 25,893 | 0.5% | 25,893 | 137.8% | 8.897 | 136.6% |
| IVC filter on or before date of first OR procedure | 3,619 | 0.1% | 678 | 3.6% | 3.893 | 3.5% |
| PA thrombectomy on or before date of first OR procedure | 122 | 0.0% | 14 | 0.1% | 3.763 | 0.1% |
| IVC filter or PA thrombec­tomy is only OR procedure | 0 | 0.0% | 0 | 0.0% | 3.760 | 0.0% |
| Intracranial or spinal cord trauma | 61,687 | 1.2% | 966 | 5.1% | 3.905 | 3.9% |
| Extracorporeal membrane oxygenation | 4,039 | 0.1% | 200 | 1.1% | 3.797 | 1.0% |
| MDC 14 (obstetrics) | 12,896 | 0.3% | 4 | 0.0% | 3.751 | -0.2% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category; OR – operating room; DVT – deep vein thrombosis; PE – pulmonary embolism; IVC – inferior vena cava; PA – pulmonary arterial*

**Table 15h. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Postoperative Sepsis (PSI 13)**

| **PSI 13** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 2,537,482 | - | 12,142 | - | 4.785 | - |
| Principal diagnosis of sepsis | 0 | 0.0% | 0 | 0.0% | 4.785 | 0.0% |
| Secondary diagnosis of sepsis present on admission | 0 | 0.0% | 0 | 0.0% | 4.785 | 0.0% |
| Principal diagnosis of bacterial infection | 98,630 | 3.9% | 720 | 5.9% | 4.879 | 2.0% |
| Secondary diagnosis of bacterial infection present on admission | 3,444 | 0.1% | 3,444 | 28.4% | 6.134 | 28.2% |
| MDC 14 (obstetrics) | 6,930 | 0.3% | 4 | 0.0% | 4.774 | -0.2% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category*

**Table 15i. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Postoperative Wound Dehiscence (PSI 14)**

| **PSI 14** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 1,094,111 | - | 1,000 | - | 0.914 | - |
| Wound closure on or before date of first OR procedure | 3,916 | 0.4% | 402 | 40.2% | 1.277 | 39.7% |
| Principal diagnosis of disruption of surgical wound or secondary diagnosis of disruption of surgical wound present on admission | 4,398 | 0.4% | 105 | 10.5% | 1.006 | 10.1% |
| Diagnosis or procedure indicating immuno­compromised state | 246,221 | 22.5% | 483 | 48.3% | 1.106 | 21.1% |
| LOS < 2 days | 105,746 | 9.7% | 0 | 0.0% | 0.833 | -8.8% |
| MDC 14 (obstetrics) | 3,514 | 0.3% | 0 | 0.0% | 0.911 | -0.3% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: LOS – length of stay; MDC – major diagnostic category; OR – operating room*

**Table 15j. Impact of Denominator Exclusion Criteria on Denominator Count, Numerator Count, and Observed National Rate per 1000, Unrecognized Abdominopelvic Accidental Puncture or Laceration (PSI 15)**

| **PSI 15** | **Denominator Count (N)** | **Denominator Percent Change** | **Numerator Count (N)** | **Numerator Percent Change** | **Rate per 1,000 Dropping Exclusion** | **Rate per 1,000 Percent Change** |
| --- | --- | --- | --- | --- | --- | --- |
| **Current specification** | 3,098,185 | - | 3,910 | - | 1.262 | - |
| Principal diagnosis of accidental puncture or laceration | 3,524 | 0.1% | 5 | 0.1% | 1.262 | 0.0% |
| Secondary diagnosis of accidental puncture or laceration present on admission | 526 | 0.0% | 526 | 13.5% | 1.432 | 13.4% |
| MDC 14 (obstetrics) | 7,378 | 0.2% | 4 | 0.1% | 1.260 | -0.1% |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*Abbreviations: MDC – major diagnostic category*

**2b2.3. What is your interpretation of the results in terms of demonstrating that exclusions are needed to prevent unfair distortion of performance results?** (*i.e., the value outweighs the burden of increased data collection and analysis. Note:* ***If patient preference is an exclusion****, the measure must be specified so that the effect on the performance score is transparent, e.g., scores with and without exclusion*)

Several exclusions are applied to each indicator because they are part of the inherent design of the Patient Safety Indicators. First, all indicators (**Tables 15a-15j**) exclude cases with a qualifying complication code in the principal position, because these diagnoses are present on admission based on the definition of “principal diagnosis” as “the condition established after study to be chiefly responsible for occasioning the admission of the patient for care.” Second, all indicators exclude cases with a qualifying complication code in a secondary position but classified as “present on admission” (POA)(including “clinically undetermined”), because it is not appropriate to attribute such complications to that hospital. For PSI 13 (**Table 15h**), these “principal diagnosis” and “secondary diagnosis present POA” exclusions are applied not just to the numerator-triggering diagnosis of sepsis, but also to associated bacterial infections. For PSI 10 (**Table 15e**), these exclusions are applied not just to the numerator-triggering diagnosis of acute kidney failure, but also to associated conditions such as cardiac arrest or ventricular arhythmia, shock, or stage 5 chronic kidney disease. Third, obstetric patients (MDC=14) are excluded from all indicators (**Tables 15a-15j**) because these patients are at very low risk for PSI 90 events, and when they are at risk, different and less specific ICD-10-CM codes are typically used. Completely different technical specifications would be needed for the obstetric population. Fourth, the indicators that involve procedures as part of their numerator definitions (**Tables 15d-15g, 15i**) all have exclusions for situations where the numerator-triggering (or numerator-related, for PSIs 11 and 12) procedure is the only operating room procedure or preceded the procedure(s) that qualified the record for the denominator. This last scenario merits exclusion because it suggests that the complication of interest developed preoperatively rather than postoperatively. Although dropping these four types of denominator exclusions would have a substantial quantitative impact, as shown in **Tables 15a-15j**, they cannot be dropped because they help to operationalize each indicator’s focus on complications that occurred during that hospital stay and/or after an OR procedure.

Additional exclusions are applied on an indicator-specific basis to reduce the false positive rate or to exclude patients for whom expert panel members agreed that the indicator event is essentially nonpreventable. For example, length of stay exclusions are applied to PSI 03 (**Table 15a**) and PSI 14 (**Table 15i**) because of previous findings (from clinical research corroborated by chart review studies) that these complications almost never arise within that length-of-stay period. Patients with severe burns or exfoliative disorders of the skin, affecting at least 20% of body surface area, are excluded from PSI 03 (**Table 15a**) because they are at very high risk for additional skin injury and it is often infeasible to turn them frequently. Similarly, patients with intracranial or spinal cord trauma are excluded from PSI 12 (**Table 15g**) because they cannot receive pharmacologic thromboprophylaxis, while patients on extracorporeal membrane oxygenation are excluded because they have a very high risk of venous thromboembolism despite pharmacologic thromboprophylaxis. Patients receiving procedures that require traversing the pleural space are excluded from PSI 06 (**Table 15b**) because this indicator focuses on patients in whom the pleural space is inadvertently entered (e.g., during central venous catheterization). Patients requiring prolonged intubation to protect a vulnerable airway during facial, oropharyngeal, or laryngeal surgery are excluded from PSI 11 (**Table 15f**) because this indicator uses prolonged intubation as a numerator trigger suggesting respiratory failure.

None of the PSI exclusions imposes a burden by increasing the complexity of data collection or analysis, because they use standard claims data elements and are embedded within the public-use software. None of the PSI exclusions is based on patient or provider preference. All of the PSI exclusions have been recommended or endorsed by expert panels convened by AHRQ and/or CMS.

# 2b3. RISK ADJUSTMENT/STRATIFICATION FOR OUTCOME OR RESOURCE USE MEASURES

***Note:*** *Applies to all outcome or resource use component measures, unless already endorsed or are being submitted for individual endorsement.*

## If not an intermediate or health outcome, or PRO-PM, or resource use measure, skip to section [2b4.](#_bookmark8)

**2b3.1. What method of controlling for differences in case mix is used?** *(check all that apply)*

# Endorsed (or submitted) as individual performance measures

* **No risk adjustment or stratification**

**Statistical risk model with 49 (PSI 14B) - 135 (PSI 03) risk factors**

* **Stratification by** Click here to enter number of categories **risk categories**
* **Other,** Click here to enter description

# 2b3.1.1 If using statistical risk models, provide detailed risk model specifications, including the risk model method, risk factors, coefficients, equations, codes with descriptors, and definitions.

Each of the PSI component risk models is shown below in **Tables 16a-16k** with risk factor names and denominator prevalences, coefficient estimates, and 95% confidence intervals surrounding those coefficient estimates. **Tables 16 i-16j** represent risk models for two versions of PSI 14; PSI 14A reflects postoperative wound dehiscence with an open approach and PSI 14B reflects the same complication with a laparoscopic, endoscopic, or percutaneous approach. In each model, risk factors are listed in the following sequence:

* Age categories, generally 5 years in width, using the youngest category as the omitted referent
* Sex categories, using female as the omitted referent
* Two-way age-sex interactions, which allow for different age-outcome relationships among men versus women
* AHRQ (Elixhauser) comorbidities, coded using publicly available HCUP software[[10]](#footnote-11)
* Major Diagnostic Categories (MDCs) based on the body system of the principal diagnosis[[11]](#footnote-12)
* Modified Diagnosis Related Groups (MDRGs), based on aggregation of adjacent MS-DRGs with or without comorbidities and complications[[12]](#footnote-13)
* Admission by transfer in from another hospital

**Table 16a. PSI 03 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -6.9393 | -7.1295 | -6.7491 | 0.0000 |
| Age\_50\_54 | 428,693 | 0.0493 | -0.2124 | 0.3110 | 0.7120 |
| Age\_55\_59 | 641,627 | 0.4157 | 0.1870 | 0.6444 | 0.0004 |
| Age\_60\_64 | 798,260 | 0.3956 | 0.1791 | 0.6121 | 0.0003 |
| Age\_65\_69 | 2,152,971 | 0.2864 | 0.0976 | 0.4752 | 0.0030 |
| Age\_70\_74 | 2,129,934 | 0.2864 | 0.1058 | 0.4670 | 0.0019 |
| Age\_75\_79 | 1,997,245 | 0.4518 | 0.2662 | 0.6373 | 0.0000 |
| Age\_80\_84 | 1,808,102 | 0.3704 | 0.1812 | 0.5595 | 0.0001 |
| Age\_85\_89 | 1,539,535 | 0.2810 | 0.0877 | 0.4743 | 0.0044 |
| Age\_90Plus | 1,217,648 | 0.2798 | 0.0701 | 0.4894 | 0.0089 |
| MALE | 6,152,581 | 0.1975 | -0.0073 | 0.4024 | 0.0588 |
| Age\_50\_54\*MALE | 220,247 | 0.1783 | -0.1524 | 0.5091 | 0.2906 |
| Age\_55\_59\*MALE | 329,821 | -0.1949 | -0.4789 | 0.0892 | 0.1787 |
| Age\_60\_64\*MALE | 406,944 | -0.0610 | -0.3306 | 0.2086 | 0.6576 |
| Age\_65\_69\*MALE | 1,071,254 | -0.0236 | -0.2579 | 0.2108 | 0.8437 |
| Age\_70\_74\*MALE | 1,024,245 | -0.0118 | -0.2379 | 0.2143 | 0.9186 |
| Age\_75\_79\*MALE | 927,267 | -0.1334 | -0.3554 | 0.0886 | 0.2388 |
| Age\_80\_84\*MALE | 788,061 | -0.0524 | -0.2886 | 0.1838 | 0.6639 |
| Age\_85\_89\*MALE | 611,629 | -0.0275 | -0.2729 | 0.2179 | 0.8261 |
| Age\_90Plus\*MALE | 398,523 | -0.0707 | -0.3468 | 0.2053 | 0.6155 |
| DM | 1,812,405 | -0.1696 | -0.2588 | -0.0804 | 0.0002 |
| CHF | 2,523,499 | 0.6575 | 0.5973 | 0.7178 | 0.0000 |
| ARTH | 608,252 | -0.0667 | -0.1882 | 0.0548 | 0.2819 |
| COAG | 947,840 | 0.1231 | 0.0549 | 0.1913 | 0.0004 |
| DMCX | 3,015,976 | 0.3197 | 0.2629 | 0.3765 | 0.0000 |
| METS | 427,596 | 0.0926 | -0.0153 | 0.2004 | 0.0926 |
| PARA | 652,603 | 0.9632 | 0.8930 | 1.0335 | 0.0000 |
| HTN\_C | 8,919,910 | -0.3905 | -0.4426 | -0.3384 | 0.0000 |
| LIVER | 597,668 | -0.1205 | -0.2198 | -0.0212 | 0.0174 |
| LYMPH | 164,994 | -0.0966 | -0.2820 | 0.0887 | 0.3068 |
| LYTES | 4,584,880 | 0.3168 | 0.2655 | 0.3680 | 0.0000 |
| NEURO | 1,705,282 | 0.1905 | 0.1285 | 0.2525 | 0.0000 |
| OBESE | 2,211,313 | -0.0728 | -0.1387 | -0.0069 | 0.0305 |
| PSYCH | 579,218 | 0.1229 | 0.0122 | 0.2337 | 0.0296 |
| TUMOR | 432,435 | -0.1160 | -0.2359 | 0.0039 | 0.0580 |
| ULCER | 148,708 | 0.2295 | 0.0730 | 0.3859 | 0.0041 |
| VALVE | 970,433 | -0.2394 | -0.3299 | -0.1488 | 0.0000 |
| ALCOHOL | 408,480 | -0.1447 | -0.2804 | -0.0091 | 0.0365 |
| ANEMDEF | 3,415,573 | -0.0651 | -0.1224 | -0.0079 | 0.0258 |
| BLDLOSS | 153,760 | 0.0389 | -0.1474 | 0.2251 | 0.6826 |
| DEPRESS | 2,071,963 | -0.3796 | -0.4550 | -0.3043 | 0.0000 |
| HYPOTHY | 2,656,060 | -0.3659 | -0.4340 | -0.2979 | 0.0000 |
| CHRNLUNG | 3,723,966 | -0.3068 | -0.3591 | -0.2544 | 0.0000 |
| PERIVASC | 1,218,098 | 0.0927 | 0.0272 | 0.1582 | 0.0055 |
| PULMCIRC | 417,600 | 0.2096 | 0.1023 | 0.3169 | 0.0001 |
| RENLFAIL | 3,554,904 | 0.1960 | 0.1391 | 0.2530 | 0.0000 |
| WGHTLOSS | 1,271,554 | 1.1675 | 1.1092 | 1.2258 | 0.0000 |
| MDC\_1 | 1,003,014 | -1.1050 | -1.2696 | -0.9404 | 0.0000 |
| MDC\_3 | 81,467 | -1.3694 | -1.7045 | -1.0342 | 0.0000 |
| MDC\_4 | 1,911,180 | -0.2771 | -0.4139 | -0.1403 | 0.0001 |
| MDC\_6 | 1,401,245 | -1.1827 | -1.3309 | -1.0344 | 0.0000 |
| MDC\_7 | 398,613 | -1.6503 | -1.8437 | -1.4569 | 0.0000 |
| MDC\_8 | 1,700,694 | -0.8931 | -1.0159 | -0.7704 | 0.0000 |
| MDC\_9 | 314,500 | -0.9360 | -1.1818 | -0.6902 | 0.0000 |
| MDC\_10 | 462,721 | -1.0667 | -1.2840 | -0.8494 | 0.0000 |
| MDC\_11 | 1,048,492 | -1.1485 | -1.3132 | -0.9838 | 0.0000 |
| MDC\_12 | 41,734 | -1.5918 | -2.1290 | -1.0547 | 0.0000 |
| MDC\_13 | 47,645 | -1.5774 | -2.1206 | -1.0343 | 0.0000 |
| MDC\_16 | 185,029 | -1.4871 | -1.8257 | -1.1485 | 0.0000 |
| MDC\_17 | 109,212 | -1.2364 | -1.5100 | -0.9628 | 0.0000 |
| MDC\_19 | 184,580 | -1.8724 | -2.4968 | -1.2480 | 0.0000 |
| MDC\_20 | 91,079 | -2.2090 | -2.7955 | -1.6225 | 0.0000 |
| MDC\_21 | 171,233 | -0.6190 | -0.8633 | -0.3747 | 0.0000 |
| MDRG\_103 | 59,807 | -0.5754 | -1.0346 | -0.1163 | 0.0140 |
| MDRG\_104 | 11,993 | 1.1051 | 0.7046 | 1.5057 | 0.0000 |
| MDRG\_108 | 20,462 | 1.0442 | 0.7353 | 1.3530 | 0.0000 |
| MDRG\_114 | 304,059 | -0.7314 | -0.9924 | -0.4705 | 0.0000 |
| MDRG\_118 | 34,491 | -1.6837 | -2.6622 | -0.7052 | 0.0007 |
| MDRG\_125 | 59,376 | -0.7300 | -1.1996 | -0.2604 | 0.0023 |
| MDRG\_128 | 89,378 | -0.9362 | -1.4010 | -0.4713 | 0.0001 |
| MDRG\_401 | 61,062 | -0.5456 | -0.8742 | -0.2170 | 0.0011 |
| MDRG\_403 | 79,788 | -2.5291 | -3.1900 | -1.8681 | 0.0000 |
| MDRG\_404 | 183,778 | -1.2082 | -1.4220 | -0.9944 | 0.0000 |
| MDRG\_405 | 46,299 | -1.5970 | -2.0991 | -1.0949 | 0.0000 |
| MDRG\_406 | 27,654 | -2.8628 | -4.3680 | -1.3576 | 0.0002 |
| MDRG\_408 | 235,550 | -1.6209 | -1.9457 | -1.2962 | 0.0000 |
| MDRG\_409 | 439,619 | -2.7845 | -3.1256 | -2.4433 | 0.0000 |
| MDRG\_410 | 437,751 | -1.8956 | -2.1356 | -1.6557 | 0.0000 |
| MDRG\_411 | 18,860 | -2.6824 | -4.2322 | -1.1326 | 0.0007 |
| MDRG\_413 | 63,545 | -4.4049 | -6.6131 | -2.1968 | 0.0001 |
| MDRG\_416 | 124,853 | -0.3368 | -0.5237 | -0.1499 | 0.0004 |
| MDRG\_503 | 89,127 | -0.1032 | -0.2941 | 0.0876 | 0.2890 |
| MDRG\_505 | 16,186 | -0.6012 | -1.1274 | -0.0750 | 0.0251 |
| MDRG\_507 | 114,562 | -0.6900 | -0.9189 | -0.4612 | 0.0000 |
| MDRG\_509 | 33,181 | 0.4005 | 0.2007 | 0.6004 | 0.0001 |
| MDRG\_510 | 90,824 | -1.6854 | -2.0745 | -1.2963 | 0.0000 |
| MDRG\_511 | 147,482 | -2.3070 | -2.7037 | -1.9103 | 0.0000 |
| MDRG\_514 | 114,381 | -0.8282 | -1.0567 | -0.5997 | 0.0000 |
| MDRG\_515 | 8,361 | -1.0460 | -1.7876 | -0.3044 | 0.0057 |
| MDRG\_517 | 10,400 | -1.2004 | -2.0154 | -0.3854 | 0.0039 |
| MDRG\_520 | 213,117 | -1.8885 | -2.1574 | -1.6195 | 0.0000 |
| MDRG\_522 | 140,375 | -2.1538 | -2.5533 | -1.7543 | 0.0000 |
| MDRG\_524 | 764,434 | -2.0281 | -2.2010 | -1.8552 | 0.0000 |
| MDRG\_526 | 2,909 | 0.1643 | -0.6218 | 0.9504 | 0.6821 |
| MDRG\_527 | 77,619 | -1.6872 | -2.1005 | -1.2740 | 0.0000 |
| MDRG\_529 | 45,080 | -4.0844 | -5.6767 | -2.4920 | 0.0000 |
| MDRG\_531 | 251,190 | -2.3571 | -2.7099 | -2.0043 | 0.0000 |
| MDRG\_533 | 79,548 | -3.9946 | -5.4448 | -2.5445 | 0.0000 |
| MDRG\_535 | 97,319 | -1.5866 | -1.8743 | -1.2989 | 0.0000 |
| MDRG\_540 | 40,248 | -1.7141 | -2.3417 | -1.0865 | 0.0000 |
| MDRG\_541 | 19,076 | -0.2418 | -0.6544 | 0.1708 | 0.2507 |
| MDRG\_542 | 57,121 | -0.2639 | -0.4940 | -0.0339 | 0.0245 |
| MDRG\_543 | 30,150 | -1.8713 | -2.6728 | -1.0697 | 0.0000 |
| MDRG\_601 | 50,755 | 0.3791 | 0.0826 | 0.6756 | 0.0122 |
| MDRG\_602 | 212,677 | 0.5156 | 0.3171 | 0.7141 | 0.0000 |
| MDRG\_614 | 39,126 | -0.5376 | -0.9940 | -0.0813 | 0.0209 |
| MDRG\_615 | 298,309 | -0.9529 | -1.2229 | -0.6830 | 0.0000 |
| MDRG\_619 | 139,199 | -1.2830 | -1.7052 | -0.8608 | 0.0000 |
| MDRG\_620 | 253,999 | -1.6213 | -2.0116 | -1.2310 | 0.0000 |
| MDRG\_706 | 4,882 | 1.2226 | 0.4765 | 1.9686 | 0.0013 |
| MDRG\_806 | 56,953 | -0.6162 | -1.1216 | -0.1107 | 0.0169 |
| MDRG\_807 | 516,280 | -0.6772 | -0.8794 | -0.4749 | 0.0000 |
| MDRG\_834 | 99,202 | -1.0851 | -1.5124 | -0.6577 | 0.0000 |
| MDRG\_839 | 49,346 | -1.0200 | -1.6198 | -0.4203 | 0.0009 |
| MDRG\_910 | 202,943 | -1.2233 | -1.6112 | -0.8354 | 0.0000 |
| MDRG\_1007 | 129,515 | -0.6016 | -0.9568 | -0.2463 | 0.0009 |
| MDRG\_1008 | 202,363 | -0.5768 | -0.9040 | -0.2495 | 0.0006 |
| MDRG\_1102 | 13,201 | 0.7752 | 0.1965 | 1.3538 | 0.0086 |
| MDRG\_1104 | 18,452 | 0.1046 | -0.4557 | 0.6648 | 0.7145 |
| MDRG\_1109 | 25,290 | 0.5966 | 0.2930 | 0.9002 | 0.0001 |
| MDRG\_1110 | 391,682 | -0.9325 | -1.1454 | -0.7195 | 0.0000 |
| MDRG\_1113 | 327,045 | -0.9120 | -1.1601 | -0.6638 | 0.0000 |
| MDRG\_1604 | 107,320 | -1.2930 | -1.9647 | -0.6214 | 0.0002 |
| MDRG\_1708 | 9,268 | 1.2555 | 0.7481 | 1.7629 | 0.0000 |
| MDRG\_1801 | 178,767 | 0.3420 | 0.2359 | 0.4481 | 0.0000 |
| MDRG\_1807 | 56,211 | 0.4054 | 0.2578 | 0.5530 | 0.0000 |
| MDRG\_1808 | 1,202,526 | -1.2325 | -1.3564 | -1.1087 | 0.0000 |
| MDRG\_1915 | 130,488 | -1.6975 | -2.7906 | -0.6044 | 0.0023 |
| MDRG\_2104 | 33,368 | 0.0124 | -0.3850 | 0.4099 | 0.9511 |
| MDRG\_2107 | 64,592 | -1.5039 | -2.0944 | -0.9133 | 0.0000 |
| MDRG\_2303 | 56,563 | -2.0671 | -2.6760 | -1.4581 | 0.0000 |
| MDRG\_2406 | 789 | 0.8576 | -0.0600 | 1.7752 | 0.0670 |
| MDRG\_2408 | 7,631 | 0.1912 | -0.3302 | 0.7127 | 0.4723 |
| MDRG\_7701 | 4,765 | 1.7734 | 1.4741 | 2.0727 | 0.0000 |
| TRNSFER | 900,717 | 0.6103 | 0.5261 | 0.6944 | 0.0000 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16b. PSI 06 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -8.9678 | -9.2417 | -8.6938 | 0.0000 |
| Age\_50\_54 | 575,901 | 0.1466 | -0.2738 | 0.5670 | 0.4944 |
| Age\_55\_59 | 846,152 | 0.2961 | -0.0629 | 0.6551 | 0.1060 |
| Age\_60\_64 | 1,031,400 | 0.4993 | 0.1680 | 0.8306 | 0.0031 |
| Age\_65\_69 | 2,949,377 | 0.6135 | 0.3270 | 0.9000 | 0.0000 |
| Age\_70\_74 | 2,831,610 | 0.6324 | 0.3440 | 0.9209 | 0.0000 |
| Age\_75\_79 | 2,563,445 | 0.6633 | 0.3757 | 0.9510 | 0.0000 |
| Age\_80\_84 | 2,260,597 | 0.7519 | 0.4660 | 1.0378 | 0.0000 |
| Age\_85\_89 | 1,876,023 | 0.6605 | 0.3736 | 0.9474 | 0.0000 |
| Age\_90Plus | 1,463,804 | 0.5989 | 0.3112 | 0.8867 | 0.0000 |
| MALE | 8,013,134 | -0.1792 | -0.5495 | 0.1912 | 0.3431 |
| Age\_50\_54\*MALE | 295,697 | 0.0189 | -0.5521 | 0.5898 | 0.9484 |
| Age\_55\_59\*MALE | 435,323 | -0.1434 | -0.6396 | 0.3527 | 0.5710 |
| Age\_60\_64\*MALE | 525,830 | -0.5306 | -1.0510 | -0.0103 | 0.0456 |
| Age\_65\_69\*MALE | 1,464,382 | -0.3621 | -0.7643 | 0.0402 | 0.0777 |
| Age\_70\_74\*MALE | 1,364,214 | -0.4828 | -0.8867 | -0.0789 | 0.0191 |
| Age\_75\_79\*MALE | 1,193,600 | -0.2116 | -0.6073 | 0.1841 | 0.2947 |
| Age\_80\_84\*MALE | 990,096 | -0.2173 | -0.6220 | 0.1874 | 0.2926 |
| Age\_85\_89\*MALE | 748,832 | -0.1689 | -0.5716 | 0.2339 | 0.4112 |
| Age\_90Plus\*MALE | 479,084 | -0.0828 | -0.4990 | 0.3335 | 0.6967 |
| DM | 2,457,820 | -0.4884 | -0.5904 | -0.3864 | 0.0000 |
| DMCX | 3,610,862 | -0.4102 | -0.5051 | -0.3153 | 0.0000 |
| DRUG | 390,137 | -0.0639 | -0.3306 | 0.2028 | 0.6387 |
| PARA | 812,454 | 0.2555 | 0.1161 | 0.3950 | 0.0003 |
| HTN\_C | 11,543,196 | -0.0568 | -0.1191 | 0.0055 | 0.0739 |
| LIVER | 697,298 | 0.0939 | -0.0751 | 0.2630 | 0.2760 |
| LYMPH | 188,691 | -0.3017 | -0.6407 | 0.0374 | 0.0812 |
| LYTES | 5,368,647 | 0.0647 | -0.0045 | 0.1339 | 0.0670 |
| NEURO | 2,078,347 | 0.0094 | -0.0855 | 0.1043 | 0.8456 |
| OBESE | 2,768,015 | -0.6502 | -0.7647 | -0.5357 | 0.0000 |
| PSYCH | 734,606 | 0.0325 | -0.1492 | 0.2141 | 0.7261 |
| ALCOHOL | 497,807 | -0.1086 | -0.3219 | 0.1047 | 0.3184 |
| ANEMDEF | 3,930,571 | -0.0841 | -0.1626 | -0.0056 | 0.0357 |
| BLDLOSS | 177,041 | -0.0988 | -0.4189 | 0.2213 | 0.5452 |
| DEPRESS | 2,609,164 | -0.1827 | -0.2779 | -0.0874 | 0.0002 |
| HYPOTHY | 3,344,457 | 0.0039 | -0.0737 | 0.0815 | 0.9218 |
| CHRNLUNG | 4,481,843 | 0.0919 | 0.0189 | 0.1650 | 0.0137 |
| PERIVASC | 1,465,865 | -0.0090 | -0.1137 | 0.0957 | 0.8668 |
| PULMCIRC | 441,588 | 0.1242 | -0.0689 | 0.3173 | 0.2076 |
| RENLFAIL | 4,237,449 | -0.1419 | -0.2228 | -0.0611 | 0.0006 |
| WGHTLOSS | 1,326,399 | 0.7815 | 0.6919 | 0.8712 | 0.0000 |
| MDRG\_102 | 25,009 | 1.9448 | 1.5880 | 2.3017 | 0.0000 |
| MDRG\_103 | 76,034 | 1.0590 | 0.7232 | 1.3947 | 0.0000 |
| MDRG\_111 | 80,860 | -1.0837 | -1.9631 | -0.2043 | 0.0157 |
| MDRG\_114 | 438,859 | -0.5115 | -0.8105 | -0.2125 | 0.0008 |
| MDRG\_116 | 90,376 | -2.6664 | -4.5982 | -0.7345 | 0.0068 |
| MDRG\_125 | 84,701 | -1.2502 | -2.2332 | -0.2673 | 0.0127 |
| MDRG\_401 | 1,531 | 2.4877 | 1.3485 | 3.6269 | 0.0000 |
| MDRG\_402 | 17,407 | 1.9506 | 1.5008 | 2.4005 | 0.0000 |
| MDRG\_403 | 107,092 | -2.1924 | -3.5945 | -0.7903 | 0.0022 |
| MDRG\_404 | 194,986 | -0.5151 | -0.9244 | -0.1059 | 0.0136 |
| MDRG\_405 | 23,934 | 2.0638 | 1.7468 | 2.3807 | 0.0000 |
| MDRG\_409 | 577,886 | -1.5239 | -1.9609 | -1.0869 | 0.0000 |
| MDRG\_410 | 532,478 | -1.3912 | -1.8007 | -0.9817 | 0.0000 |
| MDRG\_415 | 28,042 | 0.5888 | -0.1008 | 1.2783 | 0.0942 |
| MDRG\_416 | 131,506 | 2.1636 | 2.0031 | 2.3241 | 0.0000 |
| MDRG\_504 | 30,051 | 4.0963 | 3.9391 | 4.2535 | 0.0000 |
| MDRG\_510 | 121,273 | 4.1828 | 4.0901 | 4.2755 | 0.0000 |
| MDRG\_517 | 12,909 | 2.5651 | 2.1610 | 2.9693 | 0.0000 |
| MDRG\_520 | 312,810 | -0.6099 | -0.9938 | -0.2260 | 0.0018 |
| MDRG\_527 | 112,284 | -1.8031 | -2.9345 | -0.6717 | 0.0018 |
| MDRG\_531 | 431,669 | -0.8796 | -1.2384 | -0.5208 | 0.0000 |
| MDRG\_533 | 140,318 | -2.0332 | -3.1388 | -0.9275 | 0.0003 |
| MDRG\_534 | 94,480 | -2.5475 | -4.4160 | -0.6790 | 0.0075 |
| MDRG\_540 | 61,652 | 1.7391 | 1.4712 | 2.0071 | 0.0000 |
| MDRG\_542 | 62,474 | 1.0421 | 0.6425 | 1.4416 | 0.0000 |
| MDRG\_601 | 28,995 | 1.6977 | 1.3468 | 2.0486 | 0.0000 |
| MDRG\_602 | 222,646 | 0.9932 | 0.7883 | 1.1981 | 0.0000 |
| MDRG\_613 | 105,146 | -0.6889 | -1.3097 | -0.0682 | 0.0296 |
| MDRG\_615 | 413,056 | -0.6779 | -1.0120 | -0.3437 | 0.0001 |
| MDRG\_620 | 382,412 | -1.2219 | -1.6575 | -0.7864 | 0.0000 |
| MDRG\_701 | 19,025 | 2.5986 | 2.2720 | 2.9253 | 0.0000 |
| MDRG\_705 | 100,940 | 0.2974 | -0.1335 | 0.7282 | 0.1761 |
| MDRG\_710 | 107,509 | -0.9815 | -1.7865 | -0.1765 | 0.0169 |
| MDRG\_711 | 73,623 | 0.2046 | -0.3448 | 0.7540 | 0.4654 |
| MDRG\_803 | 148,391 | 0.6330 | 0.2868 | 0.9792 | 0.0003 |
| MDRG\_806 | 86,007 | -0.9978 | -1.8811 | -0.1145 | 0.0268 |
| MDRG\_807 | 1,015,380 | -2.1594 | -2.6104 | -1.7083 | 0.0000 |
| MDRG\_834 | 123,374 | -1.1259 | -1.8649 | -0.3868 | 0.0028 |
| MDRG\_910 | 263,653 | -1.8032 | -2.5958 | -1.0107 | 0.0000 |
| MDRG\_1006 | 16,866 | 0.1180 | -1.2900 | 1.5260 | 0.8695 |
| MDRG\_1007 | 193,031 | -0.7022 | -1.2092 | -0.1952 | 0.0066 |
| MDRG\_1008 | 310,221 | -1.1557 | -1.6669 | -0.6444 | 0.0000 |
| MDRG\_1103 | 31,148 | 2.9087 | 2.6613 | 3.1561 | 0.0000 |
| MDRG\_1110 | 516,018 | -0.8801 | -1.2079 | -0.5522 | 0.0000 |
| MDRG\_1113 | 433,522 | -2.7751 | -3.6399 | -1.9104 | 0.0000 |
| MDRG\_1118 | 186,582 | -0.3913 | -0.8308 | 0.0482 | 0.0810 |
| MDRG\_1604 | 162,649 | -2.6188 | -4.0270 | -1.2107 | 0.0003 |
| MDRG\_1801 | 164,985 | 1.4625 | 1.2690 | 1.6560 | 0.0000 |
| MDRG\_1807 | 53,271 | 2.6611 | 2.4776 | 2.8445 | 0.0000 |
| MDRG\_1808 | 1,408,885 | 0.3504 | 0.2264 | 0.4745 | 0.0000 |
| MDRG\_2107 | 102,944 | -0.5964 | -1.2947 | 0.1018 | 0.0941 |
| MDRG\_2303 | 83,930 | -2.6617 | -4.6295 | -0.6938 | 0.0080 |
| TRNSFER | 1,026,048 | 0.0838 | -0.0221 | 0.1897 | 0.1208 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16c. PSI 08 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -9.9985 | -10.5228 | -9.4743 | 0.0000 |
| Age\_50\_54 | 510,084 | 0.7705 | 0.0581 | 1.4828 | 0.0340 |
| Age\_55\_59 | 757,409 | 1.0670 | 0.4340 | 1.7000 | 0.0010 |
| Age\_60\_64 | 929,797 | 1.1878 | 0.5809 | 1.7948 | 0.0001 |
| Age\_65\_69 | 2,663,640 | 1.1644 | 0.6073 | 1.7214 | 0.0000 |
| Age\_70\_74 | 2,545,816 | 1.3821 | 0.8312 | 1.9330 | 0.0000 |
| Age\_75\_79 | 2,269,167 | 1.7965 | 1.2569 | 2.3360 | 0.0000 |
| Age\_80\_84 | 1,951,860 | 1.9602 | 1.4160 | 2.5045 | 0.0000 |
| Age\_85\_89 | 1,581,625 | 2.2947 | 1.7532 | 2.8362 | 0.0000 |
| Age\_90Plus | 1,226,182 | 2.4635 | 1.9118 | 3.0152 | 0.0000 |
| MALE | 7,115,396 | 0.3595 | -0.3382 | 1.0571 | 0.3125 |
| Age\_50\_54\*MALE | 260,106 | -0.4069 | -1.4002 | 0.5864 | 0.4221 |
| Age\_55\_59\*MALE | 388,940 | -1.0322 | -1.9918 | -0.0726 | 0.0350 |
| Age\_60\_64\*MALE | 474,901 | -0.5756 | -1.4071 | 0.2559 | 0.1749 |
| Age\_65\_69\*MALE | 1,329,729 | -1.0357 | -1.7985 | -0.2729 | 0.0078 |
| Age\_70\_74\*MALE | 1,235,807 | -0.9858 | -1.7360 | -0.2355 | 0.0100 |
| Age\_75\_79\*MALE | 1,067,050 | -0.7246 | -1.4491 | -0.0001 | 0.0500 |
| Age\_80\_84\*MALE | 867,987 | -0.8070 | -1.5382 | -0.0757 | 0.0306 |
| Age\_85\_89\*MALE | 645,346 | -0.8004 | -1.5430 | -0.0579 | 0.0346 |
| Age\_90Plus\*MALE | 414,163 | -0.8973 | -1.6472 | -0.1475 | 0.0190 |
| DM | 2,153,452 | -0.1918 | -0.3603 | -0.0234 | 0.0256 |
| CHF | 2,639,203 | 0.5177 | 0.3888 | 0.6467 | 0.0000 |
| ARTH | 697,441 | 0.1836 | -0.0177 | 0.3848 | 0.0739 |
| COAG | 889,895 | 0.1549 | -0.0421 | 0.3519 | 0.1232 |
| DMCX | 3,348,070 | -0.2011 | -0.3431 | -0.0591 | 0.0055 |
| DRUG | 318,823 | 0.1993 | -0.1851 | 0.5837 | 0.3095 |
| PARA | 686,649 | 0.0921 | -0.1568 | 0.3410 | 0.4685 |
| HTN\_C | 9,977,703 | -0.1443 | -0.2605 | -0.0280 | 0.0150 |
| LIVER | 643,704 | 0.1759 | -0.0770 | 0.4288 | 0.1728 |
| LYTES | 4,796,163 | 0.3363 | 0.2183 | 0.4542 | 0.0000 |
| NEURO | 1,858,374 | 0.5296 | 0.3981 | 0.6611 | 0.0000 |
| OBESE | 2,600,487 | -0.4509 | -0.6101 | -0.2917 | 0.0000 |
| PSYCH | 639,916 | -0.0130 | -0.3143 | 0.2884 | 0.9327 |
| TUMOR | 482,527 | 0.3476 | 0.1016 | 0.5935 | 0.0056 |
| ULCER | 153,491 | -0.2406 | -0.7271 | 0.2459 | 0.3324 |
| VALVE | 977,977 | 0.2416 | 0.0792 | 0.4041 | 0.0036 |
| ALCOHOL | 418,213 | 0.6098 | 0.3206 | 0.8990 | 0.0000 |
| ANEMDEF | 3,540,532 | 0.2395 | 0.1160 | 0.3630 | 0.0001 |
| BLDLOSS | 159,127 | 0.2732 | -0.1298 | 0.6762 | 0.1840 |
| DEPRESS | 2,277,988 | 0.1681 | 0.0391 | 0.2971 | 0.0106 |
| HYPOTHY | 2,938,632 | -0.0482 | -0.1677 | 0.0714 | 0.4299 |
| CHRNLUNG | 4,144,493 | 0.4246 | 0.3162 | 0.5329 | 0.0000 |
| PERIVASC | 1,374,451 | -0.0384 | -0.2093 | 0.1324 | 0.6592 |
| PULMCIRC | 401,845 | 0.5920 | 0.3781 | 0.8059 | 0.0000 |
| RENLFAIL | 3,920,745 | 0.1457 | 0.0211 | 0.2703 | 0.0219 |
| WGHTLOSS | 1,171,064 | 0.7278 | 0.5788 | 0.8769 | 0.0000 |
| MDRG\_103 | 40,137 | -1.2430 | -2.6244 | 0.1384 | 0.0778 |
| MDRG\_107 | 74,110 | -1.6138 | -2.7480 | -0.4797 | 0.0053 |
| MDRG\_111 | 80,533 | -1.9305 | -2.9000 | -0.9610 | 0.0001 |
| MDRG\_117 | 69,792 | -1.8098 | -2.6915 | -0.9281 | 0.0001 |
| MDRG\_125 | 80,092 | -2.2414 | -3.3736 | -1.1092 | 0.0001 |
| MDRG\_401 | 55,916 | -2.7125 | -4.6447 | -0.7802 | 0.0059 |
| MDRG\_402 | 38,048 | -2.7369 | -4.6856 | -0.7883 | 0.0059 |
| MDRG\_403 | 103,654 | -3.0085 | -4.3871 | -1.6299 | 0.0000 |
| MDRG\_404 | 204,440 | -2.7740 | -3.4301 | -2.1178 | 0.0000 |
| MDRG\_405 | 23,784 | -1.8233 | -3.2022 | -0.4443 | 0.0096 |
| MDRG\_408 | 298,364 | -3.5068 | -4.3858 | -2.6278 | 0.0000 |
| MDRG\_409 | 578,500 | -2.3139 | -2.7851 | -1.8427 | 0.0000 |
| MDRG\_410 | 537,005 | -2.9462 | -3.4570 | -2.4353 | 0.0000 |
| MDRG\_415 | 28,900 | -2.4601 | -4.4057 | -0.5145 | 0.0132 |
| MDRG\_416 | 140,785 | -2.7399 | -3.6127 | -1.8670 | 0.0000 |
| MDRG\_503 | 91,072 | -1.4787 | -2.4547 | -0.5027 | 0.0030 |
| MDRG\_507 | 113,483 | -1.4665 | -2.4383 | -0.4948 | 0.0031 |
| MDRG\_509 | 35,708 | -1.0800 | -2.0602 | -0.0999 | 0.0308 |
| MDRG\_510 | 25,727 | 0.0267 | -0.6638 | 0.7171 | 0.9396 |
| MDRG\_511 | 257,637 | -1.6367 | -2.2601 | -1.0133 | 0.0000 |
| MDRG\_514 | 138,628 | -0.7672 | -1.2710 | -0.2633 | 0.0028 |
| MDRG\_520 | 312,009 | -2.3424 | -2.9410 | -1.7439 | 0.0000 |
| MDRG\_522 | 199,347 | -3.8162 | -5.7509 | -1.8814 | 0.0001 |
| MDRG\_524 | 963,251 | -2.4901 | -2.8506 | -2.1297 | 0.0000 |
| MDRG\_527 | 108,195 | -3.1225 | -4.4967 | -1.7483 | 0.0000 |
| MDRG\_529 | 82,329 | -3.4781 | -5.4251 | -1.5311 | 0.0005 |
| MDRG\_531 | 429,443 | -2.8768 | -3.5733 | -2.1804 | 0.0000 |
| MDRG\_533 | 60,463 | -3.1460 | -5.0891 | -1.2028 | 0.0015 |
| MDRG\_534 | 93,585 | -2.0509 | -3.1696 | -0.9321 | 0.0003 |
| MDRG\_535 | 124,949 | -2.8481 | -3.9798 | -1.7165 | 0.0000 |
| MDRG\_540 | 63,043 | -1.9255 | -3.0500 | -0.8010 | 0.0008 |
| MDRG\_542 | 70,989 | -1.4487 | -2.4263 | -0.4710 | 0.0037 |
| MDRG\_543 | 34,014 | -1.3878 | -2.7549 | -0.0208 | 0.0466 |
| MDRG\_601 | 60,092 | -1.1748 | -1.9698 | -0.3798 | 0.0038 |
| MDRG\_602 | 202,597 | -1.7638 | -2.3526 | -1.1749 | 0.0000 |
| MDRG\_604 | 38,286 | -2.5501 | -4.4960 | -0.6043 | 0.0102 |
| MDRG\_611 | 20,459 | -0.2745 | -1.0772 | 0.5283 | 0.5028 |
| MDRG\_613 | 101,491 | -3.2598 | -4.6377 | -1.8820 | 0.0000 |
| MDRG\_615 | 404,679 | -3.1938 | -3.8928 | -2.4949 | 0.0000 |
| MDRG\_616 | 26,053 | -2.4506 | -4.3965 | -0.5047 | 0.0136 |
| MDRG\_619 | 185,020 | -4.2436 | -6.1800 | -2.3072 | 0.0000 |
| MDRG\_620 | 369,656 | -3.8744 | -4.9970 | -2.7518 | 0.0000 |
| MDRG\_621 | 140,357 | -4.0733 | -6.0021 | -2.1445 | 0.0000 |
| MDRG\_705 | 100,871 | -1.6784 | -2.5484 | -0.8085 | 0.0002 |
| MDRG\_708 | 50,704 | -2.8984 | -4.8625 | -0.9343 | 0.0038 |
| MDRG\_710 | 107,714 | -2.7656 | -4.1525 | -1.3787 | 0.0001 |
| MDRG\_711 | 72,158 | -2.4751 | -3.8524 | -1.0979 | 0.0004 |
| MDRG\_801 | 44,414 | -1.9911 | -3.9119 | -0.0703 | 0.0422 |
| MDRG\_805 | 36,946 | 1.1963 | 0.8220 | 1.5707 | 0.0000 |
| MDRG\_806 | 80,488 | 1.6897 | 1.4775 | 1.9020 | 0.0000 |
| MDRG\_807 | 883,807 | 0.5290 | 0.3754 | 0.6826 | 0.0000 |
| MDRG\_811 | 14,942 | 1.4344 | 1.0382 | 1.8306 | 0.0000 |
| MDRG\_812 | 108,058 | -3.0681 | -4.9887 | -1.1475 | 0.0017 |
| MDRG\_826 | 44,460 | -2.5861 | -4.5201 | -0.6520 | 0.0088 |
| MDRG\_831 | 29,405 | -2.1513 | -3.5072 | -0.7954 | 0.0019 |
| MDRG\_835 | 29,058 | -2.4331 | -4.3756 | -0.4906 | 0.0141 |
| MDRG\_838 | 22,771 | -0.4395 | -1.2429 | 0.3640 | 0.2837 |
| MDRG\_901 | 25,462 | -2.1411 | -4.0879 | -0.1943 | 0.0311 |
| MDRG\_903 | 22,901 | -1.9094 | -3.8574 | 0.0386 | 0.0547 |
| MDRG\_906 | 16,442 | -2.0968 | -4.0515 | -0.1421 | 0.0355 |
| MDRG\_910 | 257,222 | -3.3771 | -4.5028 | -2.2513 | 0.0000 |
| MDRG\_911 | 23,562 | -2.4705 | -4.4221 | -0.5190 | 0.0131 |
| MDRG\_1006 | 16,182 | 2.2378 | 1.8557 | 2.6200 | 0.0000 |
| MDRG\_1007 | 187,189 | -2.9822 | -4.1043 | -1.8602 | 0.0000 |
| MDRG\_1008 | 296,735 | -2.3848 | -3.0109 | -1.7586 | 0.0000 |
| MDRG\_1010 | 47,677 | -1.8508 | -2.8339 | -0.8677 | 0.0002 |
| MDRG\_1104 | 22,822 | -1.6446 | -3.5905 | 0.3013 | 0.0976 |
| MDRG\_1107 | 33,311 | -0.0040 | -0.6012 | 0.5933 | 0.9896 |
| MDRG\_1110 | 498,872 | -3.1202 | -3.6818 | -2.5585 | 0.0000 |
| MDRG\_1113 | 423,902 | -3.4219 | -4.1125 | -2.7314 | 0.0000 |
| MDRG\_1118 | 179,335 | -3.6405 | -5.0179 | -2.2630 | 0.0000 |
| MDRG\_1603 | 24,874 | -2.2533 | -4.2119 | -0.2948 | 0.0241 |
| MDRG\_1604 | 157,721 | -4.0841 | -6.0220 | -2.1461 | 0.0000 |
| MDRG\_1708 | 496 | 1.6368 | -0.3159 | 3.5894 | 0.1004 |
| MDRG\_1801 | 163,460 | 0.4116 | 0.1953 | 0.6280 | 0.0002 |
| MDRG\_1802 | 29,817 | -1.3852 | -2.7632 | -0.0072 | 0.0488 |
| MDRG\_1803 | 42,078 | -2.4628 | -4.4091 | -0.5166 | 0.0131 |
| MDRG\_1805 | 19,784 | -2.0438 | -3.9947 | -0.0930 | 0.0400 |
| MDRG\_1807 | 59,114 | -3.6092 | -5.5507 | -1.6678 | 0.0003 |
| MDRG\_1808 | 1,382,082 | -3.3880 | -3.7795 | -2.9964 | 0.0000 |
| MDRG\_2104 | 32,766 | 0.2242 | -0.4166 | 0.8650 | 0.4928 |
| MDRG\_2108 | 53,099 | -2.7924 | -4.7330 | -0.8518 | 0.0048 |
| MDRG\_2303 | 71,109 | -3.4290 | -5.3728 | -1.4851 | 0.0005 |
| TRNSFER | 845,901 | -0.0530 | -0.2709 | 0.1649 | 0.6337 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16d. PSI 09 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -5.7001 | -5.8302 | -5.5701 | 0.0000 |
| Age\_50\_54 | 132,043 | -0.0540 | -0.2483 | 0.1402 | 0.5857 |
| Age\_55\_59 | 205,579 | 0.0235 | -0.1430 | 0.1900 | 0.7817 |
| Age\_60\_64 | 261,478 | -0.0408 | -0.2036 | 0.1219 | 0.6227 |
| Age\_65\_69 | 1,107,700 | -0.1009 | -0.2400 | 0.0383 | 0.1554 |
| Age\_70\_74 | 971,133 | -0.0779 | -0.2133 | 0.0574 | 0.2589 |
| Age\_75\_79 | 756,172 | -0.0438 | -0.1838 | 0.0962 | 0.5401 |
| Age\_80\_84 | 524,663 | -0.0586 | -0.2000 | 0.0828 | 0.4165 |
| Age\_85\_89 | 331,813 | -0.2246 | -0.3909 | -0.0583 | 0.0081 |
| Age\_90Plus | 182,697 | -0.5824 | -0.7961 | -0.3686 | 0.0000 |
| MALE | 2,199,218 | 0.1171 | -0.0371 | 0.2712 | 0.1366 |
| Age\_50\_54\*MALE | 66,460 | 0.0590 | -0.1980 | 0.3159 | 0.6529 |
| Age\_55\_59\*MALE | 104,955 | -0.0279 | -0.2554 | 0.1995 | 0.8097 |
| Age\_60\_64\*MALE | 133,467 | -0.0281 | -0.2360 | 0.1798 | 0.7911 |
| Age\_65\_69\*MALE | 548,206 | -0.0556 | -0.2359 | 0.1248 | 0.5460 |
| Age\_70\_74\*MALE | 472,445 | -0.0382 | -0.2126 | 0.1363 | 0.6682 |
| Age\_75\_79\*MALE | 355,364 | 0.0444 | -0.1358 | 0.2247 | 0.6292 |
| Age\_80\_84\*MALE | 233,482 | -0.1042 | -0.2966 | 0.0882 | 0.2885 |
| Age\_85\_89\*MALE | 132,331 | -0.0017 | -0.2221 | 0.2186 | 0.9876 |
| Age\_90Plus\*MALE | 57,066 | 0.0205 | -0.2903 | 0.3313 | 0.8972 |
| DM | 656,170 | -0.2157 | -0.2761 | -0.1553 | 0.0000 |
| CHF | 415,582 | 0.3152 | 0.2449 | 0.3855 | 0.0000 |
| DMCX | 803,928 | -0.1416 | -0.1956 | -0.0877 | 0.0000 |
| DRUG | 56,690 | 0.0712 | -0.0947 | 0.2371 | 0.4004 |
| METS | 118,801 | 0.0747 | -0.0415 | 0.1909 | 0.2074 |
| PARA | 154,170 | 0.1499 | 0.0583 | 0.2414 | 0.0013 |
| HTN\_C | 3,195,033 | -0.0699 | -0.1124 | -0.0275 | 0.0012 |
| LYMPH | 26,948 | -0.1449 | -0.3951 | 0.1054 | 0.2565 |
| LYTES | 679,690 | -0.0652 | -0.1218 | -0.0086 | 0.0239 |
| NEURO | 366,578 | -0.0646 | -0.1426 | 0.0134 | 0.1048 |
| OBESE | 855,752 | -0.0560 | -0.1086 | -0.0033 | 0.0372 |
| PSYCH | 117,907 | -0.1181 | -0.2432 | 0.0070 | 0.0642 |
| TUMOR | 99,941 | 0.0496 | -0.0636 | 0.1627 | 0.3905 |
| ULCER | 35,576 | 0.3008 | 0.1237 | 0.4779 | 0.0009 |
| VALVE | 235,390 | 0.2537 | 0.1643 | 0.3431 | 0.0000 |
| ANEMDEF | 718,610 | -0.3052 | -0.3615 | -0.2490 | 0.0000 |
| DEPRESS | 627,328 | -0.0507 | -0.1131 | 0.0118 | 0.1116 |
| HYPOTHY | 817,500 | 0.0312 | -0.0216 | 0.0840 | 0.2467 |
| CHRNLUNG | 999,710 | -0.0121 | -0.0572 | 0.0329 | 0.5974 |
| PERIVASC | 450,953 | 0.2095 | 0.1581 | 0.2610 | 0.0000 |
| PULMCIRC | 70,955 | 0.2181 | 0.0799 | 0.3563 | 0.0020 |
| RENLFAIL | 834,723 | 0.1506 | 0.0983 | 0.2028 | 0.0000 |
| WGHTLOSS | 240,466 | 0.3812 | 0.3068 | 0.4556 | 0.0000 |
| MDRG\_103 | 45,590 | 0.4424 | 0.2929 | 0.5920 | 0.0000 |
| MDRG\_105 | 11,141 | -3.8941 | -6.6521 | -1.1361 | 0.0057 |
| MDRG\_107 | 80,435 | 0.9519 | 0.8562 | 1.0477 | 0.0000 |
| MDRG\_301 | 9,265 | 0.9284 | 0.6549 | 1.2018 | 0.0000 |
| MDRG\_401 | 63,464 | 0.1504 | 0.0165 | 0.2842 | 0.0277 |
| MDRG\_402 | 44,522 | -1.5922 | -1.9517 | -1.2327 | 0.0000 |
| MDRG\_501 | 6,975 | 1.2850 | 1.0431 | 1.5269 | 0.0000 |
| MDRG\_502 | 21,414 | -0.7015 | -1.0782 | -0.3248 | 0.0003 |
| MDRG\_503 | 61,885 | 1.4446 | 1.3453 | 1.5438 | 0.0000 |
| MDRG\_505 | 17,262 | 0.7908 | 0.5827 | 0.9989 | 0.0000 |
| MDRG\_507 | 91,869 | 0.8518 | 0.7486 | 0.9551 | 0.0000 |
| MDRG\_509 | 34,580 | -0.2276 | -0.4350 | -0.0202 | 0.0315 |
| MDRG\_510 | 24,316 | 0.1807 | -0.0465 | 0.4079 | 0.1190 |
| MDRG\_511 | 252,353 | -1.0984 | -1.2379 | -0.9589 | 0.0000 |
| MDRG\_513 | 18,404 | -0.8857 | -1.3006 | -0.4707 | 0.0000 |
| MDRG\_514 | 125,299 | 0.7732 | 0.6856 | 0.8608 | 0.0000 |
| MDRG\_540 | 56,828 | 0.1685 | 0.0043 | 0.3327 | 0.0442 |
| MDRG\_542 | 63,984 | 0.6442 | 0.5273 | 0.7610 | 0.0000 |
| MDRG\_543 | 32,802 | -0.3320 | -0.5806 | -0.0834 | 0.0088 |
| MDRG\_601 | 56,630 | 0.1032 | -0.0528 | 0.2591 | 0.1949 |
| MDRG\_602 | 219,897 | -0.0484 | -0.1413 | 0.0445 | 0.3074 |
| MDRG\_604 | 38,297 | -0.3145 | -0.5313 | -0.0977 | 0.0045 |
| MDRG\_610 | 34,454 | 0.0339 | -0.1578 | 0.2255 | 0.7292 |
| MDRG\_701 | 18,369 | 0.4187 | 0.1894 | 0.6479 | 0.0003 |
| MDRG\_704 | 12,545 | -0.4109 | -0.8327 | 0.0108 | 0.0562 |
| MDRG\_705 | 97,830 | -0.9665 | -1.1514 | -0.7816 | 0.0000 |
| MDRG\_801 | 44,081 | -0.5155 | -0.7447 | -0.2862 | 0.0000 |
| MDRG\_802 | 14,046 | -0.9914 | -1.4828 | -0.5000 | 0.0001 |
| MDRG\_803 | 146,323 | -1.0351 | -1.2089 | -0.8614 | 0.0000 |
| MDRG\_804 | 16,297 | -2.7747 | -3.9055 | -1.6438 | 0.0000 |
| MDRG\_805 | 38,608 | -0.2059 | -0.4157 | 0.0039 | 0.0544 |
| MDRG\_806 | 83,157 | -1.5602 | -1.8394 | -1.2810 | 0.0000 |
| MDRG\_807 | 992,352 | -3.3353 | -3.5482 | -3.1224 | 0.0000 |
| MDRG\_810 | 21,840 | -1.8783 | -2.4990 | -1.2577 | 0.0000 |
| MDRG\_811 | 236,468 | -2.4300 | -2.6890 | -2.1711 | 0.0000 |
| MDRG\_812 | 118,288 | -3.1610 | -3.7192 | -2.6028 | 0.0000 |
| MDRG\_816 | 73,581 | -2.7292 | -3.2609 | -2.1976 | 0.0000 |
| MDRG\_820 | 10,752 | -2.4814 | -3.6619 | -1.3009 | 0.0000 |
| MDRG\_824 | 13,271 | -3.7106 | -5.7797 | -1.6415 | 0.0004 |
| MDRG\_826 | 59,004 | -0.8242 | -1.0654 | -0.5830 | 0.0000 |
| MDRG\_903 | 24,764 | 1.4842 | 1.3664 | 1.6020 | 0.0000 |
| MDRG\_904 | 2,986 | 1.8351 | 1.5655 | 2.1048 | 0.0000 |
| MDRG\_1002 | 31,187 | -0.6974 | -0.9977 | -0.3971 | 0.0000 |
| MDRG\_1003 | 35,940 | -0.3958 | -0.6437 | -0.1479 | 0.0018 |
| MDRG\_1005 | 7,014 | 1.8789 | 1.6953 | 2.0626 | 0.0000 |
| MDRG\_1101 | 19,301 | 1.2712 | 1.0757 | 1.4668 | 0.0000 |
| MDRG\_1105 | 2,447 | 1.5812 | 1.2509 | 1.9115 | 0.0000 |
| MDRG\_1107 | 33,910 | -2.2114 | -2.7979 | -1.6249 | 0.0000 |
| MDRG\_1109 | 16,766 | 0.4357 | 0.2136 | 0.6578 | 0.0001 |
| MDRG\_1201 | 35,643 | -1.0904 | -1.4311 | -0.7498 | 0.0000 |
| MDRG\_1801 | 145,402 | -0.4291 | -0.5532 | -0.3049 | 0.0000 |
| MDRG\_1802 | 27,225 | 0.1684 | -0.0405 | 0.3773 | 0.1141 |
| MDRG\_7701 | 2,622 | 2.7287 | 2.4747 | 2.9828 | 0.0000 |
| MDRG\_7702 | 1,335 | 2.1648 | 1.7867 | 2.5430 | 0.0000 |
| TRNSFER | 281,730 | 0.0749 | 0.0055 | 0.1443 | 0.0343 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16e. PSI 10 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -6.9103 | -7.2645 | -6.5560 | 0.0000 |
| Age\_50\_54 | 62,454 | 0.3542 | -0.1545 | 0.8630 | 0.1724 |
| Age\_55\_59 | 101,156 | 0.3975 | -0.0441 | 0.8391 | 0.0777 |
| Age\_60\_64 | 133,063 | 0.6368 | 0.2273 | 1.0463 | 0.0023 |
| Age\_65\_69 | 725,867 | 0.6383 | 0.2756 | 1.0010 | 0.0006 |
| Age\_70\_74 | 624,659 | 0.8406 | 0.4841 | 1.1971 | 0.0000 |
| Age\_75\_79 | 453,477 | 1.0206 | 0.6511 | 1.3901 | 0.0000 |
| Age\_80\_84 | 261,672 | 0.8675 | 0.4922 | 1.2429 | 0.0000 |
| Age\_85\_89 | 119,509 | 0.6024 | 0.1812 | 1.0235 | 0.0051 |
| Age\_90Plus | 35,578 | 0.0299 | -0.5396 | 0.5995 | 0.9179 |
| MALE | 1,185,883 | 0.5064 | 0.0739 | 0.9389 | 0.0217 |
| Age\_50\_54\*MALE | 26,185 | -0.4082 | -1.0765 | 0.2601 | 0.2312 |
| Age\_55\_59\*MALE | 44,529 | -0.5303 | -1.1058 | 0.0452 | 0.0709 |
| Age\_60\_64\*MALE | 60,035 | -0.3757 | -0.8946 | 0.1433 | 0.1560 |
| Age\_65\_69\*MALE | 337,303 | -0.2429 | -0.6949 | 0.2092 | 0.2923 |
| Age\_70\_74\*MALE | 290,624 | -0.4330 | -0.8788 | 0.0129 | 0.0570 |
| Age\_75\_79\*MALE | 208,372 | -0.5056 | -0.9713 | -0.0398 | 0.0334 |
| Age\_80\_84\*MALE | 118,980 | -0.4760 | -0.9484 | -0.0035 | 0.0483 |
| Age\_85\_89\*MALE | 52,671 | -0.5199 | -1.0440 | 0.0043 | 0.0519 |
| Age\_90Plus\*MALE | 14,196 | -0.5571 | -1.3447 | 0.2305 | 0.1657 |
| DM | 397,850 | -0.4746 | -0.6215 | -0.3277 | 0.0000 |
| CHF | 127,469 | 1.3133 | 1.1709 | 1.4557 | 0.0000 |
| ARTH | 122,091 | -0.1824 | -0.3741 | 0.0093 | 0.0622 |
| COAG | 58,876 | 0.4857 | 0.3605 | 0.6109 | 0.0000 |
| DMCX | 280,440 | 0.2285 | 0.1379 | 0.3192 | 0.0000 |
| METS | 51,976 | -0.0380 | -0.2278 | 0.1518 | 0.6945 |
| PARA | 41,030 | -0.0008 | -0.2363 | 0.2348 | 0.9949 |
| HTN\_C | 1,759,849 | -0.6938 | -0.7666 | -0.6209 | 0.0000 |
| LIVER | 57,161 | 0.3150 | 0.1455 | 0.4845 | 0.0003 |
| LYTES | 130,666 | 0.3594 | 0.2505 | 0.4684 | 0.0000 |
| NEURO | 142,699 | -0.3609 | -0.5337 | -0.1882 | 0.0000 |
| OBESE | 518,186 | 0.3400 | 0.2546 | 0.4254 | 0.0000 |
| PSYCH | 50,708 | -0.4897 | -0.8486 | -0.1309 | 0.0075 |
| TUMOR | 43,413 | 0.0661 | -0.1436 | 0.2757 | 0.5368 |
| ULCER | 12,065 | 0.3725 | 0.0394 | 0.7055 | 0.0284 |
| VALVE | 106,753 | 0.1989 | 0.0300 | 0.3678 | 0.0210 |
| ALCOHOL | 28,141 | -0.4563 | -0.7983 | -0.1143 | 0.0089 |
| ANEMDEF | 226,759 | -0.1888 | -0.3015 | -0.0762 | 0.0010 |
| DEPRESS | 349,545 | -0.5115 | -0.6457 | -0.3774 | 0.0000 |
| HYPOTHY | 451,108 | -0.2301 | -0.3307 | -0.1296 | 0.0000 |
| CHRNLUNG | 516,913 | 0.0283 | -0.0583 | 0.1149 | 0.5217 |
| PERIVASC | 199,026 | 0.2398 | 0.1508 | 0.3288 | 0.0000 |
| PULMCIRC | 21,231 | 0.7712 | 0.5557 | 0.9867 | 0.0000 |
| RENLFAIL | 296,259 | 1.0682 | 0.9742 | 1.1622 | 0.0000 |
| WGHTLOSS | 54,608 | 0.9248 | 0.8033 | 1.0464 | 0.0000 |
| MDRG\_103 | 34,825 | -1.8497 | -2.4919 | -1.2076 | 0.0000 |
| MDRG\_106 | 9,266 | -2.2346 | -3.4271 | -1.0421 | 0.0002 |
| MDRG\_107 | 66,297 | -2.2649 | -2.7432 | -1.7867 | 0.0000 |
| MDRG\_401 | 49,590 | -0.5351 | -0.7931 | -0.2771 | 0.0000 |
| MDRG\_402 | 13,627 | -1.5657 | -2.2331 | -0.8983 | 0.0000 |
| MDRG\_501 | 1,773 | 1.7990 | 1.4529 | 2.1451 | 0.0000 |
| MDRG\_503 | 64,645 | 1.3707 | 1.2490 | 1.4923 | 0.0000 |
| MDRG\_505 | 11,569 | 0.5835 | 0.3181 | 0.8489 | 0.0000 |
| MDRG\_507 | 56,925 | 0.6659 | 0.5067 | 0.8250 | 0.0000 |
| MDRG\_509 | 10,692 | -1.0021 | -1.4180 | -0.5863 | 0.0000 |
| MDRG\_511 | 26,252 | -0.5868 | -0.9189 | -0.2547 | 0.0005 |
| MDRG\_514 | 52,988 | -1.0825 | -1.3742 | -0.7907 | 0.0000 |
| MDRG\_540 | 52,784 | -0.5117 | -0.7402 | -0.2831 | 0.0000 |
| MDRG\_541 | 32,336 | 0.4521 | 0.2351 | 0.6690 | 0.0000 |
| MDRG\_542 | 23,228 | 0.6904 | 0.4860 | 0.8947 | 0.0000 |
| MDRG\_543 | 11,367 | -1.4336 | -2.2096 | -0.6576 | 0.0003 |
| MDRG\_601 | 35,373 | -0.0458 | -0.2837 | 0.1921 | 0.7060 |
| MDRG\_610 | 19,580 | -1.0857 | -1.5816 | -0.5897 | 0.0000 |
| MDRG\_701 | 16,416 | 0.6095 | 0.3828 | 0.8361 | 0.0000 |
| MDRG\_705 | 9,753 | -1.2483 | -1.9167 | -0.5800 | 0.0003 |
| MDRG\_801 | 41,948 | -1.4433 | -1.9144 | -0.9721 | 0.0000 |
| MDRG\_803 | 135,772 | -1.8684 | -2.2059 | -1.5310 | 0.0000 |
| MDRG\_804 | 16,178 | -2.1501 | -3.1669 | -1.1332 | 0.0000 |
| MDRG\_805 | 19,616 | -1.1940 | -1.7115 | -0.6765 | 0.0000 |
| MDRG\_806 | 67,265 | -2.0005 | -2.4825 | -1.5185 | 0.0000 |
| MDRG\_807 | 863,572 | -3.0915 | -3.3452 | -2.8378 | 0.0000 |
| MDRG\_808 | 64,454 | -2.3771 | -2.9918 | -1.7625 | 0.0000 |
| MDRG\_809 | 5,797 | -2.5733 | -4.0016 | -1.1451 | 0.0004 |
| MDRG\_811 | 13,808 | -2.4888 | -3.6464 | -1.3313 | 0.0000 |
| MDRG\_812 | 112,013 | -4.1583 | -5.2125 | -3.1041 | 0.0000 |
| MDRG\_815 | 30,071 | -2.2630 | -3.0677 | -1.4582 | 0.0000 |
| MDRG\_816 | 18,107 | -2.3562 | -3.3576 | -1.3548 | 0.0000 |
| MDRG\_819 | 8,530 | -1.4329 | -2.3092 | -0.5566 | 0.0014 |
| MDRG\_826 | 29,346 | -1.8074 | -2.4285 | -1.1863 | 0.0000 |
| MDRG\_901 | 6,434 | -2.2940 | -3.6888 | -0.8991 | 0.0013 |
| MDRG\_1002 | 5,692 | -1.1448 | -1.8371 | -0.4524 | 0.0012 |
| MDRG\_1003 | 34,691 | -1.1348 | -1.6523 | -0.6174 | 0.0000 |
| MDRG\_1102 | 11,593 | 0.3592 | 0.0762 | 0.6422 | 0.0129 |
| MDRG\_1201 | 31,912 | -1.6599 | -2.2507 | -1.0691 | 0.0000 |
| MDRG\_1304 | 19,885 | -1.8514 | -2.7466 | -0.9561 | 0.0001 |
| MDRG\_7701 | 1,215 | 1.7954 | 1.4159 | 2.1749 | 0.0000 |
| MDRG\_7702 | 726 | 1.6732 | 1.1782 | 2.1682 | 0.0000 |
| TRNSFER | 30,066 | 0.0079 | -0.1888 | 0.2047 | 0.9370 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16f. PSI 11 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -5.8684 | -5.9900 | -5.7468 | 0.0000 |
| Age\_50\_54 | 55,758 | 0.1962 | 0.0246 | 0.3678 | 0.0250 |
| Age\_55\_59 | 86,870 | 0.2912 | 0.1386 | 0.4439 | 0.0002 |
| Age\_60\_64 | 111,034 | 0.3415 | 0.1957 | 0.4873 | 0.0000 |
| Age\_65\_69 | 617,105 | 0.1657 | 0.0399 | 0.2915 | 0.0098 |
| Age\_70\_74 | 511,862 | 0.2755 | 0.1485 | 0.4025 | 0.0000 |
| Age\_75\_79 | 354,222 | 0.3937 | 0.2635 | 0.5239 | 0.0000 |
| Age\_80\_84 | 190,940 | 0.4198 | 0.2799 | 0.5597 | 0.0000 |
| Age\_85\_89 | 77,992 | 0.5330 | 0.3754 | 0.6906 | 0.0000 |
| Age\_90Plus | 19,675 | 0.3012 | 0.0678 | 0.5347 | 0.0114 |
| MALE | 895,569 | 0.3786 | 0.2180 | 0.5391 | 0.0000 |
| Age\_50\_54\*MALE | 22,421 | -0.2775 | -0.5269 | -0.0281 | 0.0292 |
| Age\_55\_59\*MALE | 35,995 | -0.3618 | -0.5823 | -0.1413 | 0.0013 |
| Age\_60\_64\*MALE | 46,778 | -0.2916 | -0.4987 | -0.0846 | 0.0058 |
| Age\_65\_69\*MALE | 269,277 | -0.2560 | -0.4322 | -0.0798 | 0.0044 |
| Age\_70\_74\*MALE | 221,921 | -0.2528 | -0.4299 | -0.0758 | 0.0051 |
| Age\_75\_79\*MALE | 150,130 | -0.2269 | -0.4077 | -0.0461 | 0.0139 |
| Age\_80\_84\*MALE | 79,407 | -0.2372 | -0.4315 | -0.0429 | 0.0167 |
| Age\_85\_89\*MALE | 31,174 | -0.1188 | -0.3374 | 0.0997 | 0.2865 |
| Age\_90Plus\*MALE | 7,118 | 0.0455 | -0.2831 | 0.3740 | 0.7862 |
| DM | 324,522 | -0.0498 | -0.1028 | 0.0032 | 0.0653 |
| CHF | 110,312 | 0.8659 | 0.8172 | 0.9147 | 0.0000 |
| COAG | 35,658 | 0.6011 | 0.5229 | 0.6793 | 0.0000 |
| DMCX | 192,402 | 0.2686 | 0.2179 | 0.3192 | 0.0000 |
| DRUG | 15,762 | 0.3564 | 0.2109 | 0.5020 | 0.0000 |
| METS | 35,272 | 0.2103 | 0.1274 | 0.2931 | 0.0000 |
| PARA | 31,050 | 0.7019 | 0.6168 | 0.7870 | 0.0000 |
| LIVER | 47,014 | 0.0793 | -0.0074 | 0.1659 | 0.0729 |
| LYTES | 96,041 | 0.7218 | 0.6718 | 0.7718 | 0.0000 |
| NEURO | 106,331 | 0.2735 | 0.2058 | 0.3412 | 0.0000 |
| OBESE | 433,819 | 0.4147 | 0.3731 | 0.4562 | 0.0000 |
| PSYCH | 42,832 | 0.3132 | 0.2111 | 0.4154 | 0.0000 |
| TUMOR | 29,801 | 0.1814 | 0.0859 | 0.2770 | 0.0002 |
| ULCER | 9,324 | 0.5620 | 0.4162 | 0.7078 | 0.0000 |
| VALVE | 96,255 | 0.1427 | 0.0755 | 0.2099 | 0.0000 |
| ALCOHOL | 19,795 | 0.5331 | 0.4140 | 0.6523 | 0.0000 |
| DEPRESS | 295,241 | 0.0458 | -0.0043 | 0.0959 | 0.0732 |
| CHRNLUNG | 378,580 | 0.4074 | 0.3679 | 0.4469 | 0.0000 |
| PERIVASC | 93,563 | 0.2248 | 0.1617 | 0.2879 | 0.0000 |
| PULMCIRC | 17,953 | 0.6963 | 0.6021 | 0.7904 | 0.0000 |
| RENLFAIL | 201,181 | 0.3263 | 0.2776 | 0.3750 | 0.0000 |
| WGHTLOSS | 35,849 | 0.9324 | 0.8728 | 0.9920 | 0.0000 |
| MDRG\_103 | 33,336 | 0.7779 | 0.6790 | 0.8769 | 0.0000 |
| MDRG\_107 | 64,783 | -0.3126 | -0.4247 | -0.2006 | 0.0000 |
| MDRG\_601 | 29,624 | 1.2245 | 1.1425 | 1.3065 | 0.0000 |
| MDRG\_602 | 124,216 | 0.8451 | 0.7880 | 0.9022 | 0.0000 |
| MDRG\_604 | 10,268 | 0.9452 | 0.8039 | 1.0866 | 0.0000 |
| MDRG\_610 | 19,250 | 0.6698 | 0.5480 | 0.7917 | 0.0000 |
| MDRG\_701 | 15,837 | 1.2246 | 1.1218 | 1.3274 | 0.0000 |
| MDRG\_704 | 4,541 | 0.7627 | 0.5476 | 0.9779 | 0.0000 |
| MDRG\_705 | 9,297 | 0.4482 | 0.2844 | 0.6121 | 0.0000 |
| MDRG\_801 | 40,831 | 0.5015 | 0.3986 | 0.6043 | 0.0000 |
| MDRG\_802 | 11,143 | 1.0480 | 0.9093 | 1.1868 | 0.0000 |
| MDRG\_803 | 133,033 | -0.3740 | -0.4646 | -0.2834 | 0.0000 |
| MDRG\_804 | 16,009 | -1.2407 | -1.6278 | -0.8536 | 0.0000 |
| MDRG\_805 | 18,700 | -0.4538 | -0.6418 | -0.2657 | 0.0000 |
| MDRG\_806 | 65,441 | -1.0466 | -1.2036 | -0.8895 | 0.0000 |
| MDRG\_807 | 849,090 | -1.4688 | -1.5384 | -1.3992 | 0.0000 |
| MDRG\_812 | 109,768 | -1.0928 | -1.2261 | -0.9594 | 0.0000 |
| MDRG\_815 | 29,365 | -0.6888 | -0.8884 | -0.4892 | 0.0000 |
| MDRG\_816 | 17,234 | -0.6468 | -0.8719 | -0.4218 | 0.0000 |
| MDRG\_826 | 28,023 | -0.6600 | -0.8517 | -0.4684 | 0.0000 |
| MDRG\_901 | 5,876 | -0.7769 | -1.1135 | -0.4404 | 0.0000 |
| MDRG\_1002 | 5,702 | -1.0633 | -1.4104 | -0.7163 | 0.0000 |
| MDRG\_1003 | 34,675 | -0.2880 | -0.4587 | -0.1173 | 0.0009 |
| MDRG\_1102 | 11,239 | 1.0390 | 0.9114 | 1.1666 | 0.0000 |
| MDRG\_1103 | 28,337 | 0.6297 | 0.5241 | 0.7352 | 0.0000 |
| MDRG\_1201 | 34,024 | -0.9860 | -1.2325 | -0.7394 | 0.0000 |
| MDRG\_1801 | 6,466 | 0.8874 | 0.7705 | 1.0043 | 0.0000 |
| MDRG\_2104 | 11,199 | 0.6049 | 0.4634 | 0.7464 | 0.0000 |
| MDRG\_7702 | 753 | 1.6956 | 1.4105 | 1.9807 | 0.0000 |
| TRNSFER | 15,233 | 0.3351 | 0.2281 | 0.4420 | 0.0000 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16g. PSI 12 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -5.8200 | -5.9390 | -5.7010 | 0.0000 |
| Age\_50\_54 | 141,816 | 0.0594 | -0.1181 | 0.2368 | 0.5121 |
| Age\_55\_59 | 220,771 | 0.1307 | -0.0161 | 0.2776 | 0.0811 |
| Age\_60\_64 | 281,724 | 0.1795 | 0.0311 | 0.3279 | 0.0178 |
| Age\_65\_69 | 1,170,762 | 0.2038 | 0.0878 | 0.3199 | 0.0006 |
| Age\_70\_74 | 1,032,194 | 0.3027 | 0.1814 | 0.4240 | 0.0000 |
| Age\_75\_79 | 809,941 | 0.4245 | 0.3026 | 0.5463 | 0.0000 |
| Age\_80\_84 | 566,314 | 0.3582 | 0.2350 | 0.4815 | 0.0000 |
| Age\_85\_89 | 359,615 | 0.3907 | 0.2607 | 0.5207 | 0.0000 |
| Age\_90Plus | 198,129 | 0.2954 | 0.1529 | 0.4378 | 0.0000 |
| MALE | 2,387,789 | 0.1636 | 0.0049 | 0.3223 | 0.0434 |
| Age\_50\_54\*MALE | 72,184 | -0.0059 | -0.2531 | 0.2412 | 0.9624 |
| Age\_55\_59\*MALE | 113,661 | -0.0787 | -0.2945 | 0.1371 | 0.4747 |
| Age\_60\_64\*MALE | 145,212 | -0.0670 | -0.2703 | 0.1363 | 0.5182 |
| Age\_65\_69\*MALE | 586,421 | -0.0512 | -0.2202 | 0.1178 | 0.5528 |
| Age\_70\_74\*MALE | 508,992 | -0.0852 | -0.2585 | 0.0881 | 0.3354 |
| Age\_75\_79\*MALE | 387,902 | -0.1876 | -0.3621 | -0.0131 | 0.0351 |
| Age\_80\_84\*MALE | 258,219 | -0.1432 | -0.3208 | 0.0343 | 0.1139 |
| Age\_85\_89\*MALE | 147,492 | -0.1476 | -0.3370 | 0.0418 | 0.1268 |
| Age\_90Plus\*MALE | 64,002 | -0.2263 | -0.4501 | -0.0025 | 0.0475 |
| DM | 692,470 | -0.2222 | -0.2699 | -0.1745 | 0.0000 |
| CHF | 467,077 | 0.3253 | 0.2778 | 0.3728 | 0.0000 |
| ARTH | 222,522 | 0.0349 | -0.0388 | 0.1086 | 0.3533 |
| COAG | 205,037 | 0.3081 | 0.2515 | 0.3647 | 0.0000 |
| DMCX | 883,241 | -0.1557 | -0.2040 | -0.1074 | 0.0000 |
| METS | 128,138 | 0.6548 | 0.5941 | 0.7156 | 0.0000 |
| PARA | 160,863 | 0.3498 | 0.2796 | 0.4199 | 0.0000 |
| HTN\_C | 3,403,973 | -0.1633 | -0.1955 | -0.1311 | 0.0000 |
| LYMPH | 33,438 | 0.2125 | 0.0713 | 0.3537 | 0.0032 |
| LYTES | 769,718 | 0.3678 | 0.3290 | 0.4067 | 0.0000 |
| NEURO | 394,040 | 0.0236 | -0.0301 | 0.0773 | 0.3884 |
| OBESE | 912,025 | 0.3350 | 0.2950 | 0.3749 | 0.0000 |
| TUMOR | 111,352 | 0.3100 | 0.2339 | 0.3861 | 0.0000 |
| ULCER | 41,825 | 0.4716 | 0.3673 | 0.5758 | 0.0000 |
| VALVE | 261,065 | -0.0145 | -0.0787 | 0.0498 | 0.6587 |
| ALCOHOL | 92,776 | -0.0811 | -0.1860 | 0.0237 | 0.1294 |
| ANEMDEF | 805,335 | -0.0780 | -0.1227 | -0.0334 | 0.0006 |
| BLDLOSS | 40,410 | 0.0941 | -0.0358 | 0.2240 | 0.1556 |
| DEPRESS | 666,987 | -0.1050 | -0.1511 | -0.0590 | 0.0000 |
| HYPOTHY | 874,959 | -0.1167 | -0.1589 | -0.0745 | 0.0000 |
| CHRNLUNG | 1,075,812 | 0.0224 | -0.0151 | 0.0600 | 0.2412 |
| PERIVASC | 497,263 | -0.0069 | -0.0573 | 0.0436 | 0.7900 |
| PULMCIRC | 71,035 | 0.6720 | 0.5858 | 0.7583 | 0.0000 |
| RENLFAIL | 943,353 | -0.0213 | -0.0663 | 0.0237 | 0.3534 |
| WGHTLOSS | 275,295 | 0.6483 | 0.6007 | 0.6959 | 0.0000 |
| MDRG\_102 | 16,445 | 0.0192 | -0.1942 | 0.2326 | 0.8600 |
| MDRG\_103 | 48,881 | 0.0035 | -0.1499 | 0.1568 | 0.9647 |
| MDRG\_104 | 12,504 | 0.1679 | -0.0775 | 0.4133 | 0.1800 |
| MDRG\_106 | 12,577 | -1.8884 | -2.6855 | -1.0913 | 0.0000 |
| MDRG\_107 | 81,830 | -2.4594 | -2.8424 | -2.0765 | 0.0000 |
| MDRG\_301 | 9,413 | -0.9661 | -1.4285 | -0.5036 | 0.0000 |
| MDRG\_401 | 66,092 | -0.1365 | -0.2637 | -0.0093 | 0.0354 |
| MDRG\_402 | 46,520 | -0.3490 | -0.4894 | -0.2086 | 0.0000 |
| MDRG\_502 | 22,640 | -1.0929 | -1.4316 | -0.7542 | 0.0000 |
| MDRG\_504 | 32,135 | -1.0362 | -1.2983 | -0.7741 | 0.0000 |
| MDRG\_506 | 3,485 | 0.7758 | 0.4234 | 1.1282 | 0.0000 |
| MDRG\_509 | 35,766 | -0.4673 | -0.6530 | -0.2816 | 0.0000 |
| MDRG\_510 | 26,288 | -0.7673 | -1.0310 | -0.5036 | 0.0000 |
| MDRG\_511 | 260,642 | -1.6837 | -1.8223 | -1.5451 | 0.0000 |
| MDRG\_513 | 19,200 | -1.5223 | -2.0123 | -1.0324 | 0.0000 |
| MDRG\_514 | 137,619 | -0.6162 | -0.7361 | -0.4962 | 0.0000 |
| MDRG\_515 | 9,344 | -2.1850 | -3.1166 | -1.2534 | 0.0000 |
| MDRG\_519 | 20,218 | -0.8462 | -1.1188 | -0.5736 | 0.0000 |
| MDRG\_540 | 64,356 | -1.2052 | -1.4358 | -0.9746 | 0.0000 |
| MDRG\_541 | 41,550 | -0.7340 | -0.9443 | -0.5236 | 0.0000 |
| MDRG\_543 | 34,665 | -0.9660 | -1.2312 | -0.7007 | 0.0000 |
| MDRG\_602 | 229,541 | 0.2417 | 0.1814 | 0.3019 | 0.0000 |
| MDRG\_604 | 39,868 | 0.1932 | 0.0611 | 0.3253 | 0.0041 |
| MDRG\_605 | 13,097 | -0.7545 | -1.1432 | -0.3658 | 0.0001 |
| MDRG\_606 | 9,915 | -1.1965 | -1.7461 | -0.6469 | 0.0000 |
| MDRG\_608 | 8,803 | -1.3249 | -1.9122 | -0.7377 | 0.0000 |
| MDRG\_609 | 14,951 | -0.5647 | -0.8942 | -0.2353 | 0.0008 |
| MDRG\_610 | 35,650 | -0.1595 | -0.3399 | 0.0209 | 0.0831 |
| MDRG\_611 | 23,657 | 0.0562 | -0.1033 | 0.2157 | 0.4896 |
| MDRG\_701 | 20,576 | 0.3937 | 0.2361 | 0.5513 | 0.0000 |
| MDRG\_705 | 102,932 | -1.1467 | -1.3056 | -0.9878 | 0.0000 |
| MDRG\_801 | 45,385 | 0.3883 | 0.2445 | 0.5322 | 0.0000 |
| MDRG\_802 | 14,972 | 1.1035 | 0.9469 | 1.2602 | 0.0000 |
| MDRG\_803 | 149,056 | -0.1575 | -0.2636 | -0.0513 | 0.0036 |
| MDRG\_804 | 16,662 | 0.4403 | 0.1880 | 0.6926 | 0.0006 |
| MDRG\_805 | 40,513 | -0.0870 | -0.2407 | 0.0667 | 0.2674 |
| MDRG\_807 | 1,017,197 | -0.4856 | -0.5462 | -0.4249 | 0.0000 |
| MDRG\_808 | 75,356 | -0.7074 | -0.8816 | -0.5332 | 0.0000 |
| MDRG\_811 | 256,236 | 0.0746 | 0.0098 | 0.1393 | 0.0239 |
| MDRG\_812 | 119,993 | -1.3066 | -1.4873 | -1.1259 | 0.0000 |
| MDRG\_815 | 39,755 | -0.2662 | -0.4498 | -0.0826 | 0.0045 |
| MDRG\_816 | 76,256 | -0.4762 | -0.6167 | -0.3358 | 0.0000 |
| MDRG\_819 | 20,417 | -0.6868 | -0.9729 | -0.4007 | 0.0000 |
| MDRG\_820 | 11,134 | -1.2581 | -1.7938 | -0.7224 | 0.0000 |
| MDRG\_824 | 13,504 | -1.0564 | -1.5011 | -0.6118 | 0.0000 |
| MDRG\_826 | 60,949 | -0.3511 | -0.5066 | -0.1956 | 0.0000 |
| MDRG\_901 | 27,317 | -1.2260 | -1.5312 | -0.9208 | 0.0000 |
| MDRG\_903 | 27,002 | -1.2558 | -1.5827 | -0.9289 | 0.0000 |
| MDRG\_1002 | 32,160 | -1.4083 | -1.7491 | -1.0676 | 0.0000 |
| MDRG\_1003 | 36,235 | -1.7736 | -2.2451 | -1.3022 | 0.0000 |
| MDRG\_1004 | 14,172 | -1.1430 | -1.5871 | -0.6989 | 0.0000 |
| MDRG\_1006 | 16,888 | -0.6075 | -0.9068 | -0.3083 | 0.0001 |
| MDRG\_1101 | 21,899 | -1.0514 | -1.4446 | -0.6581 | 0.0000 |
| MDRG\_1102 | 13,974 | 0.7390 | 0.5677 | 0.9103 | 0.0000 |
| MDRG\_1103 | 31,780 | -0.0122 | -0.1988 | 0.1743 | 0.8977 |
| MDRG\_1104 | 23,670 | -0.5745 | -0.8232 | -0.3259 | 0.0000 |
| MDRG\_1107 | 35,852 | -0.7428 | -0.9566 | -0.5290 | 0.0000 |
| MDRG\_1201 | 35,998 | -1.1008 | -1.4013 | -0.8003 | 0.0000 |
| MDRG\_1302 | 7,258 | 0.8639 | 0.6260 | 1.1019 | 0.0000 |
| MDRG\_1303 | 9,576 | 0.4000 | 0.1406 | 0.6594 | 0.0025 |
| MDRG\_1708 | 9,543 | 0.1534 | -0.0786 | 0.3853 | 0.1950 |
| MDRG\_1709 | 5,539 | 0.6799 | 0.3961 | 0.9636 | 0.0000 |
| MDRG\_1801 | 171,552 | 0.1063 | 0.0433 | 0.1692 | 0.0009 |
| MDRG\_2104 | 35,990 | -0.0201 | -0.1711 | 0.1310 | 0.7946 |
| MDRG\_2407 | 8,795 | 0.9920 | 0.8021 | 1.1819 | 0.0000 |
| MDRG\_2408 | 5,138 | 1.5590 | 1.3682 | 1.7498 | 0.0000 |
| MDRG\_7701 | 4,361 | 0.8303 | 0.5532 | 1.1075 | 0.0000 |
| TRNSFER | 310,178 | 0.4990 | 0.4387 | 0.5592 | 0.0000 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16h. PSI 13 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -4.9162 | -5.0463 | -4.7862 | 0.0000 |
| Age\_50\_54 | 60,461 | 0.1570 | -0.0357 | 0.3496 | 0.1102 |
| Age\_55\_59 | 97,871 | 0.1133 | -0.0617 | 0.2884 | 0.2044 |
| Age\_60\_64 | 129,109 | 0.1475 | -0.0175 | 0.3124 | 0.0797 |
| Age\_65\_69 | 707,614 | -0.0523 | -0.1895 | 0.0848 | 0.4547 |
| Age\_70\_74 | 610,025 | 0.0524 | -0.0856 | 0.1904 | 0.4566 |
| Age\_75\_79 | 443,551 | 0.1481 | 0.0074 | 0.2887 | 0.0390 |
| Age\_80\_84 | 255,658 | 0.1230 | -0.0271 | 0.2731 | 0.1081 |
| Age\_85\_89 | 116,054 | 0.1483 | -0.0193 | 0.3159 | 0.0830 |
| Age\_90Plus | 33,856 | -0.2041 | -0.4509 | 0.0427 | 0.1051 |
| MALE | 1,161,911 | 0.1706 | -0.0040 | 0.3453 | 0.0555 |
| Age\_50\_54\*MALE | 25,280 | -0.1552 | -0.4293 | 0.1190 | 0.2673 |
| Age\_55\_59\*MALE | 42,960 | -0.0119 | -0.2545 | 0.2306 | 0.9232 |
| Age\_60\_64\*MALE | 58,206 | -0.0431 | -0.2716 | 0.1853 | 0.7113 |
| Age\_65\_69\*MALE | 330,260 | 0.0806 | -0.1103 | 0.2716 | 0.4078 |
| Age\_70\_74\*MALE | 285,286 | 0.1069 | -0.0842 | 0.2979 | 0.2730 |
| Age\_75\_79\*MALE | 204,889 | 0.1161 | -0.0778 | 0.3099 | 0.2407 |
| Age\_80\_84\*MALE | 116,948 | 0.1689 | -0.0360 | 0.3737 | 0.1061 |
| Age\_85\_89\*MALE | 51,633 | 0.1169 | -0.1124 | 0.3461 | 0.3178 |
| Age\_90Plus\*MALE | 13,754 | 0.2165 | -0.1218 | 0.5548 | 0.2097 |
| DM | 387,946 | -0.3613 | -0.4247 | -0.2978 | 0.0000 |
| CHF | 119,967 | 1.0089 | 0.9548 | 1.0631 | 0.0000 |
| COAG | 57,748 | 0.4594 | 0.3849 | 0.5338 | 0.0000 |
| DMCX | 271,439 | 0.0516 | -0.0009 | 0.1041 | 0.0542 |
| DRUG | 17,447 | 0.4957 | 0.3394 | 0.6520 | 0.0000 |
| METS | 50,828 | 0.3544 | 0.2834 | 0.4254 | 0.0000 |
| PARA | 34,907 | 0.6196 | 0.5235 | 0.7157 | 0.0000 |
| HTN\_C | 1,707,054 | -0.2862 | -0.3252 | -0.2472 | 0.0000 |
| LIVER | 55,093 | 0.1940 | 0.1065 | 0.2816 | 0.0000 |
| LYTES | 124,927 | 0.5702 | 0.5180 | 0.6223 | 0.0000 |
| NEURO | 136,400 | 0.1549 | 0.0833 | 0.2265 | 0.0000 |
| OBESE | 503,981 | 0.1421 | 0.0945 | 0.1897 | 0.0000 |
| ULCER | 11,507 | 0.4589 | 0.3027 | 0.6151 | 0.0000 |
| ALCOHOL | 26,674 | 0.2244 | 0.0944 | 0.3543 | 0.0007 |
| ANEMDEF | 224,542 | -0.1145 | -0.1663 | -0.0627 | 0.0000 |
| DEPRESS | 337,028 | -0.1121 | -0.1710 | -0.0531 | 0.0002 |
| HYPOTHY | 438,186 | -0.0946 | -0.1467 | -0.0426 | 0.0004 |
| CHRNLUNG | 500,912 | -0.0923 | -0.1371 | -0.0474 | 0.0001 |
| PERIVASC | 191,456 | 0.0847 | 0.0254 | 0.1440 | 0.0051 |
| PULMCIRC | 20,274 | 0.5275 | 0.4180 | 0.6370 | 0.0000 |
| RENLFAIL | 298,010 | 0.4421 | 0.3938 | 0.4903 | 0.0000 |
| WGHTLOSS | 47,488 | 1.2715 | 1.2185 | 1.3244 | 0.0000 |
| MDC\_1 | 132,947 | -0.9813 | -1.1104 | -0.8522 | 0.0000 |
| MDC\_4 | 66,476 | 0.8676 | 0.7251 | 1.0101 | 0.0000 |
| MDC\_7 | 29,144 | 0.6582 | 0.5680 | 0.7485 | 0.0000 |
| MDC\_9 | 21,160 | -1.3550 | -1.6159 | -1.0940 | 0.0000 |
| MDC\_10 | 60,316 | -1.3922 | -1.5562 | -1.2282 | 0.0000 |
| MDC\_12 | 46,050 | -0.4581 | -0.6737 | -0.2425 | 0.0000 |
| MDC\_17 | 12,342 | 0.2268 | 0.0754 | 0.3783 | 0.0033 |
| MDRG\_107 | 66,480 | -1.6041 | -1.9162 | -1.2919 | 0.0000 |
| MDRG\_401 | 48,645 | -1.0610 | -1.2301 | -0.8918 | 0.0000 |
| MDRG\_402 | 12,925 | -1.9952 | -2.2923 | -1.6980 | 0.0000 |
| MDRG\_503 | 65,051 | -0.0230 | -0.1090 | 0.0631 | 0.6009 |
| MDRG\_504 | 6,463 | -1.1277 | -1.5088 | -0.7467 | 0.0000 |
| MDRG\_507 | 57,782 | -0.4714 | -0.5823 | -0.3606 | 0.0000 |
| MDRG\_511 | 27,074 | -1.3106 | -1.5372 | -1.0839 | 0.0000 |
| MDRG\_514 | 53,884 | -0.9727 | -1.1118 | -0.8336 | 0.0000 |
| MDRG\_519 | 3,054 | -1.1835 | -1.5747 | -0.7922 | 0.0000 |
| MDRG\_540 | 53,447 | -1.4720 | -1.6452 | -1.2989 | 0.0000 |
| MDRG\_541 | 32,414 | -0.5878 | -0.7429 | -0.4327 | 0.0000 |
| MDRG\_601 | 35,064 | 0.6161 | 0.5332 | 0.6989 | 0.0000 |
| MDRG\_602 | 110,274 | 0.3799 | 0.3206 | 0.4392 | 0.0000 |
| MDRG\_610 | 19,666 | -0.6432 | -0.8410 | -0.4454 | 0.0000 |
| MDRG\_705 | 5,157 | -0.9027 | -1.1902 | -0.6152 | 0.0000 |
| MDRG\_801 | 41,852 | -0.8372 | -1.0009 | -0.6736 | 0.0000 |
| MDRG\_803 | 135,703 | -1.2590 | -1.3758 | -1.1422 | 0.0000 |
| MDRG\_804 | 16,136 | -1.4719 | -1.8386 | -1.1051 | 0.0000 |
| MDRG\_805 | 8,530 | -1.3070 | -1.7019 | -0.9120 | 0.0000 |
| MDRG\_806 | 60,664 | -1.9341 | -2.1596 | -1.7086 | 0.0000 |
| MDRG\_807 | 863,168 | -2.4880 | -2.5786 | -2.3975 | 0.0000 |
| MDRG\_808 | 64,514 | -1.7328 | -1.9378 | -1.5277 | 0.0000 |
| MDRG\_811 | 13,232 | -1.3518 | -1.6517 | -1.0519 | 0.0000 |
| MDRG\_812 | 111,390 | -2.6109 | -2.8519 | -2.3698 | 0.0000 |
| MDRG\_815 | 30,042 | -1.5968 | -1.8643 | -1.3294 | 0.0000 |
| MDRG\_816 | 16,565 | -1.7021 | -2.0568 | -1.3475 | 0.0000 |
| MDRG\_826 | 28,829 | -1.4926 | -1.7429 | -1.2423 | 0.0000 |
| MDRG\_1102 | 11,611 | 0.8598 | 0.7447 | 0.9749 | 0.0000 |
| MDRG\_1104 | 14,387 | -0.0469 | -0.2064 | 0.1127 | 0.5649 |
| MDRG\_1201 | 34,271 | -1.1239 | -1.4518 | -0.7959 | 0.0000 |
| MDRG\_1302 | 6,320 | 0.3694 | 0.1434 | 0.5954 | 0.0014 |
| MDRG\_1304 | 19,759 | -0.9406 | -1.2034 | -0.6779 | 0.0000 |
| MDRG\_7701 | 1,259 | 1.3342 | 1.1031 | 1.5653 | 0.0000 |
| TRNSFER | 27,069 | 0.2566 | 0.1458 | 0.3673 | 0.0000 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16i. PSI 14A Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -7.3300 | -7.9249 | -6.7351 | 0.0000 |
| Age\_50\_54 | 14,659 | 0.4037 | -0.4287 | 1.2361 | 0.3418 |
| Age\_55\_59 | 22,125 | 0.0063 | -0.8681 | 0.8807 | 0.9887 |
| Age\_60\_64 | 28,083 | 0.5928 | -0.1196 | 1.3052 | 0.1029 |
| Age\_65\_69 | 130,592 | 0.1997 | -0.4350 | 0.8345 | 0.5374 |
| Age\_70\_74 | 115,302 | 0.2199 | -0.4069 | 0.8467 | 0.4918 |
| Age\_75\_79 | 88,568 | 0.3840 | -0.2681 | 1.0361 | 0.2484 |
| Age\_80\_84 | 57,774 | 0.1797 | -0.4883 | 0.8478 | 0.5980 |
| Age\_85\_89 | 33,428 | -0.1367 | -0.8946 | 0.6213 | 0.7238 |
| Age\_90Plus | 15,215 | -0.2855 | -1.1895 | 0.6184 | 0.5358 |
| MALE | 239,954 | 0.8414 | 0.1245 | 1.5582 | 0.0214 |
| Age\_50\_54\*MALE | 6,217 | 0.3100 | -0.6979 | 1.3178 | 0.5466 |
| Age\_55\_59\*MALE | 10,004 | 0.3902 | -0.6428 | 1.4233 | 0.4591 |
| Age\_60\_64\*MALE | 13,148 | 0.0513 | -0.8220 | 0.9246 | 0.9083 |
| Age\_65\_69\*MALE | 60,913 | 0.0499 | -0.7177 | 0.8174 | 0.8986 |
| Age\_70\_74\*MALE | 54,061 | 0.1403 | -0.6160 | 0.8965 | 0.7162 |
| Age\_75\_79\*MALE | 41,217 | -0.2598 | -1.0597 | 0.5401 | 0.5244 |
| Age\_80\_84\*MALE | 26,007 | -0.0304 | -0.8621 | 0.8013 | 0.9429 |
| Age\_85\_89\*MALE | 13,773 | 0.2497 | -0.6709 | 1.1704 | 0.5950 |
| Age\_90Plus\*MALE | 5,420 | 0.5057 | -0.5966 | 1.6080 | 0.3685 |
| DM | 77,502 | -0.6523 | -0.8949 | -0.4098 | 0.0000 |
| CHF | 48,342 | 0.2508 | 0.0435 | 0.4580 | 0.0177 |
| COAG | 18,888 | -0.1632 | -0.4772 | 0.1507 | 0.3083 |
| DMCX | 59,267 | -0.5148 | -0.7583 | -0.2713 | 0.0000 |
| DRUG | 6,696 | 0.4753 | 0.0866 | 0.8639 | 0.0166 |
| METS | 31,725 | -0.1186 | -0.3625 | 0.1252 | 0.3404 |
| PARA | 15,583 | 0.1785 | -0.1456 | 0.5026 | 0.2805 |
| LIVER | 19,335 | 0.0636 | -0.2383 | 0.3656 | 0.6796 |
| LYTES | 97,230 | 0.2290 | 0.0739 | 0.3841 | 0.0038 |
| NEURO | 39,052 | 0.1565 | -0.0642 | 0.3772 | 0.1645 |
| OBESE | 98,497 | 0.1969 | 0.0238 | 0.3699 | 0.0258 |
| PSYCH | 15,219 | 0.3442 | 0.0423 | 0.6462 | 0.0255 |
| TUMOR | 18,426 | 0.0736 | -0.2123 | 0.3596 | 0.6137 |
| ULCER | 7,867 | 0.1224 | -0.2944 | 0.5392 | 0.5649 |
| VALVE | 28,367 | -0.1556 | -0.4653 | 0.1542 | 0.3250 |
| ALCOHOL | 9,904 | 0.5161 | 0.2263 | 0.8059 | 0.0005 |
| ANEMDEF | 69,969 | 0.0673 | -0.1125 | 0.2471 | 0.4631 |
| BLDLOSS | 7,065 | -0.2771 | -0.8259 | 0.2718 | 0.3225 |
| HYPOTHY | 88,773 | -0.0377 | -0.2283 | 0.1528 | 0.6981 |
| CHRNLUNG | 113,035 | 0.5593 | 0.4120 | 0.7066 | 0.0000 |
| PULMCIRC | 8,836 | 0.2053 | -0.2094 | 0.6201 | 0.3319 |
| RENLFAIL | 61,473 | 0.0894 | -0.1097 | 0.2886 | 0.3789 |
| WGHTLOSS | 35,385 | 0.5306 | 0.3483 | 0.7129 | 0.0000 |
| MDC\_1 | 3,681 | -1.3724 | -2.7958 | 0.0511 | 0.0588 |
| MDRG\_519 | 823 | 0.9363 | 0.0423 | 1.8302 | 0.0401 |
| MDRG\_541 | 4,608 | 0.6130 | 0.1280 | 1.0980 | 0.0132 |
| MDRG\_542 | 11,411 | -0.2435 | -0.7153 | 0.2283 | 0.3117 |
| MDRG\_601 | 22,310 | 0.0417 | -0.2891 | 0.3725 | 0.8049 |
| MDRG\_602 | 146,372 | 0.5108 | 0.3365 | 0.6852 | 0.0000 |
| MDRG\_604 | 24,762 | -0.3347 | -0.7188 | 0.0494 | 0.0877 |
| MDRG\_609 | 10,051 | -1.9445 | -3.0750 | -0.8141 | 0.0007 |
| MDRG\_610 | 23,528 | -2.2589 | -3.2412 | -1.2765 | 0.0000 |
| MDRG\_611 | 5,211 | -0.8844 | -1.8830 | 0.1142 | 0.0826 |
| MDRG\_704 | 11,872 | -1.0320 | -1.7388 | -0.3253 | 0.0042 |
| MDRG\_705 | 2,688 | 0.7020 | 0.0727 | 1.3312 | 0.0288 |
| MDRG\_801 | 26,031 | -2.6055 | -3.7334 | -1.4775 | 0.0000 |
| MDRG\_803 | 41,254 | -2.7369 | -3.7197 | -1.7540 | 0.0000 |
| MDRG\_819 | 559 | 1.4520 | 0.4676 | 2.4365 | 0.0038 |
| MDRG\_826 | 17,538 | -3.3333 | -5.2487 | -1.4179 | 0.0006 |
| MDRG\_1102 | 9,018 | 1.0728 | 0.7655 | 1.3800 | 0.0000 |
| MDRG\_1103 | 11,486 | 0.1062 | -0.3377 | 0.5502 | 0.6390 |
| MDRG\_1201 | 5,613 | -1.3758 | -2.5149 | -0.2367 | 0.0179 |
| MDRG\_1304 | 12,661 | -0.8589 | -1.7622 | 0.0444 | 0.0624 |
| MDRG\_1707 | 1,060 | 0.9775 | 0.0781 | 1.8768 | 0.0332 |
| MDRG\_1801 | 26,793 | 0.4013 | 0.1310 | 0.6717 | 0.0036 |
| MDRG\_2408 | 1,376 | 0.5975 | -0.3477 | 1.5428 | 0.2154 |
| TRNSFER | 23,657 | 0.3697 | 0.1209 | 0.6184 | 0.0036 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16j. PSI 14B Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -12.9040 | -14.7276 | -11.0804 | 0.0000 |
| Age\_55\_59 | 27,974 | 0.4239 | -1.7597 | 2.6074 | 0.7036 |
| Age\_65\_69 | 134,628 | 0.0361 | -1.3780 | 1.4503 | 0.9600 |
| Age\_70\_74 | 110,689 | -0.1561 | -1.6354 | 1.3233 | 0.8362 |
| Age\_75\_79 | 85,717 | -1.1120 | -3.2467 | 1.0227 | 0.3072 |
| Age\_80\_84 | 62,563 | -0.1379 | -1.8015 | 1.5258 | 0.8710 |
| Age\_85\_89 | 40,061 | 0.2156 | -1.5982 | 2.0295 | 0.8157 |
| Age\_90Plus | 19,697 | 0.2995 | -2.1014 | 2.7004 | 0.8068 |
| MALE | 278,644 | -0.5786 | -2.2348 | 1.0776 | 0.4935 |
| Age\_55\_59\*MALE | 13,752 | 1.2838 | -1.7101 | 4.2776 | 0.4007 |
| Age\_65\_69\*MALE | 69,054 | 0.7704 | -1.3304 | 2.8711 | 0.4723 |
| Age\_70\_74\*MALE | 57,031 | 0.4171 | -1.8590 | 2.6932 | 0.7195 |
| Age\_75\_79\*MALE | 43,118 | 1.6990 | -1.1029 | 4.5008 | 0.2347 |
| Age\_85\_89\*MALE | 18,633 | 0.8598 | -1.7318 | 3.4514 | 0.5156 |
| Age\_90Plus\*MALE | 8,134 | 1.6669 | -1.3017 | 4.6355 | 0.2711 |
| DM | 93,117 | -0.2218 | -1.2097 | 0.7661 | 0.6599 |
| CHF | 71,794 | 0.3645 | -0.7769 | 1.5058 | 0.5314 |
| COAG | 52,255 | -0.5970 | -2.8291 | 1.6352 | 0.6002 |
| DMCX | 86,926 | -0.2323 | -1.3695 | 0.9049 | 0.6889 |
| METS | 35,250 | 0.2550 | -0.9103 | 1.4203 | 0.6680 |
| PARA | 21,165 | 1.3258 | -0.0562 | 2.7078 | 0.0601 |
| HTN\_C | 373,037 | 0.4593 | -0.3547 | 1.2733 | 0.2688 |
| LIVER | 65,246 | -0.1473 | -1.5971 | 1.3024 | 0.8421 |
| LYTES | 165,693 | -0.1871 | -1.1168 | 0.7426 | 0.6932 |
| NEURO | 47,023 | -1.1996 | -3.2792 | 0.8800 | 0.2582 |
| OBESE | 94,264 | -0.1801 | -1.1292 | 0.7691 | 0.7100 |
| PSYCH | 17,770 | 0.1368 | -1.9578 | 2.2315 | 0.8981 |
| VALVE | 34,739 | 0.4040 | -0.7279 | 1.5359 | 0.4842 |
| ALCOHOL | 25,946 | 0.2624 | -1.6639 | 2.1886 | 0.7895 |
| ANEMDEF | 118,937 | 0.8715 | 0.1289 | 1.6141 | 0.0214 |
| BLDLOSS | 8,218 | 0.3619 | -1.7376 | 2.4615 | 0.7355 |
| DEPRESS | 73,301 | 0.1647 | -0.8117 | 1.1411 | 0.7409 |
| HYPOTHY | 96,809 | 0.0568 | -0.8736 | 0.9871 | 0.9048 |
| CHRNLUNG | 117,751 | 0.5853 | -0.2140 | 1.3846 | 0.1512 |
| PERIVASC | 33,048 | -0.1935 | -1.6668 | 1.2798 | 0.7969 |
| PULMCIRC | 14,250 | 0.0191 | -1.9727 | 2.0109 | 0.9850 |
| RENLFAIL | 94,180 | 0.1109 | -0.9085 | 1.1302 | 0.8312 |
| WGHTLOSS | 43,981 | -0.1061 | -1.4893 | 1.2771 | 0.8805 |
| MDRG\_601 | 21,935 | 3.3134 | 1.3332 | 5.2935 | 0.0010 |
| MDRG\_602 | 55,583 | 3.9737 | 2.3542 | 5.5933 | 0.0000 |
| MDRG\_609 | 2,102 | 4.3858 | 1.8458 | 6.9259 | 0.0007 |
| MDRG\_701 | 4,481 | 3.8224 | 1.1653 | 6.4796 | 0.0048 |
| MDRG\_705 | 88,776 | 2.1566 | 0.3711 | 3.9422 | 0.0179 |
| MDRG\_1003 | 20,875 | 2.2525 | -0.1988 | 4.7038 | 0.0717 |
| MDRG\_1102 | 2,953 | 4.9506 | 2.9859 | 6.9152 | 0.0000 |
| MDRG\_1103 | 14,850 | 2.7811 | 0.2959 | 5.2663 | 0.0283 |
| MDRG\_1201 | 12,521 | 4.0888 | 2.2275 | 5.9502 | 0.0000 |
| MDRG\_1801 | 25,787 | 2.8546 | 1.0116 | 4.6976 | 0.0024 |
| TRNSFER | 41,555 | 0.8208 | -0.4622 | 2.1039 | 0.2099 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**Table 16k. PSI 15 Risk-Adjustment Model: All Risk Factors with Prevalences, v10.0 Parameter Estimates with 95% Confidence Intervals, and Associated p Values**

| **Risk factor** | **Discharges (N)** | **CMS v10.0 Coefficients** | **Lower Confidence Interval** | **Upper Confidence Interval** | **p-value** |
| --- | --- | --- | --- | --- | --- |
| Intercept | -- | -7.0785 | -7.2865 | -6.8704 | 0.0000 |
| Age\_50\_54 | 101,471 | 0.2598 | -0.0389 | 0.5584 | 0.0882 |
| Age\_55\_59 | 150,379 | 0.1962 | -0.0824 | 0.4748 | 0.1676 |
| Age\_60\_64 | 186,430 | 0.2545 | -0.0056 | 0.5147 | 0.0551 |
| Age\_65\_69 | 620,346 | 0.1251 | -0.0843 | 0.3346 | 0.2415 |
| Age\_70\_74 | 561,394 | 0.2123 | 0.0027 | 0.4219 | 0.0472 |
| Age\_75\_79 | 479,393 | 0.2495 | 0.0355 | 0.4636 | 0.0223 |
| Age\_80\_84 | 381,800 | 0.2328 | 0.0152 | 0.4503 | 0.0360 |
| Age\_85\_89 | 277,173 | 0.1263 | -0.1116 | 0.3641 | 0.2981 |
| Age\_90Plus | 158,154 | -0.1133 | -0.4071 | 0.1805 | 0.4497 |
| MALE | 1,543,470 | -0.1873 | -0.4867 | 0.1121 | 0.2201 |
| Age\_50\_54\*MALE | 50,712 | 0.1800 | -0.2746 | 0.6345 | 0.4378 |
| Age\_55\_59\*MALE | 77,861 | -0.1532 | -0.5805 | 0.2742 | 0.4823 |
| Age\_60\_64\*MALE | 97,854 | -0.0162 | -0.4267 | 0.3942 | 0.9382 |
| Age\_65\_69\*MALE | 323,590 | 0.0340 | -0.2967 | 0.3648 | 0.8403 |
| Age\_70\_74\*MALE | 290,310 | -0.1465 | -0.4782 | 0.1851 | 0.3865 |
| Age\_75\_79\*MALE | 242,436 | -0.0153 | -0.3480 | 0.3174 | 0.9281 |
| Age\_80\_84\*MALE | 186,845 | 0.0950 | -0.2408 | 0.4308 | 0.5792 |
| Age\_85\_89\*MALE | 127,549 | 0.0932 | -0.2759 | 0.4623 | 0.6207 |
| Age\_90Plus\*MALE | 64,428 | 0.1014 | -0.3844 | 0.5872 | 0.6825 |
| DM | 435,277 | -0.4165 | -0.5271 | -0.3059 | 0.0000 |
| CHF | 512,891 | 0.2427 | 0.1394 | 0.3460 | 0.0000 |
| ARTH | 126,321 | 0.0978 | -0.0613 | 0.2568 | 0.2285 |
| COAG | 259,168 | 0.1822 | 0.0537 | 0.3107 | 0.0055 |
| DMCX | 585,231 | -0.2447 | -0.3516 | -0.1378 | 0.0000 |
| METS | 148,445 | -0.0318 | -0.1628 | 0.0992 | 0.6344 |
| HTN\_C | 2,108,055 | -0.1522 | -0.2209 | -0.0836 | 0.0000 |
| LIVER | 236,700 | -0.1188 | -0.2642 | 0.0266 | 0.1094 |
| LYMPH | 30,902 | -0.3778 | -0.7629 | 0.0072 | 0.0545 |
| LYTES | 990,948 | 0.1025 | 0.0223 | 0.1828 | 0.0123 |
| NEURO | 326,501 | -0.0956 | -0.2135 | 0.0223 | 0.1121 |
| OBESE | 479,188 | 0.1364 | 0.0477 | 0.2252 | 0.0026 |
| PSYCH | 104,002 | 0.1353 | -0.0414 | 0.3120 | 0.1335 |
| TUMOR | 128,818 | 0.0030 | -0.1518 | 0.1578 | 0.9698 |
| VALVE | 222,771 | -0.0825 | -0.2240 | 0.0589 | 0.2529 |
| ALCOHOL | 109,274 | -0.0257 | -0.2372 | 0.1857 | 0.8114 |
| ANEMDEF | 752,589 | -0.2696 | -0.3584 | -0.1809 | 0.0000 |
| DEPRESS | 418,865 | -0.1099 | -0.2099 | -0.0100 | 0.0311 |
| HYPOTHY | 539,355 | -0.1045 | -0.1961 | -0.0129 | 0.0253 |
| PERIVASC | 289,675 | 0.0979 | -0.0072 | 0.2030 | 0.0679 |
| PULMCIRC | 92,673 | 0.0034 | -0.1969 | 0.2037 | 0.9736 |
| RENLFAIL | 720,449 | 0.1288 | 0.0326 | 0.2249 | 0.0087 |
| WGHTLOSS | 408,572 | 0.6653 | 0.5760 | 0.7546 | 0.0000 |
| MDRG\_114 | 24,581 | -1.2382 | -2.0050 | -0.4713 | 0.0016 |
| MDRG\_401 | 5,903 | 1.0461 | 0.5432 | 1.5490 | 0.0000 |
| MDRG\_404 | 20,462 | -1.2749 | -2.0722 | -0.4776 | 0.0017 |
| MDRG\_410 | 13,335 | -2.5312 | -4.5205 | -0.5419 | 0.0126 |
| MDRG\_416 | 18,194 | -2.2935 | -3.7363 | -0.8507 | 0.0018 |
| MDRG\_503 | 7,659 | 1.6362 | 1.2983 | 1.9741 | 0.0000 |
| MDRG\_507 | 4,896 | 1.4199 | 0.9506 | 1.8893 | 0.0000 |
| MDRG\_514 | 33,813 | 0.1008 | -0.2560 | 0.4577 | 0.5797 |
| MDRG\_524 | 38,082 | -2.8307 | -4.2462 | -1.4153 | 0.0001 |
| MDRG\_540 | 3,045 | 2.0402 | 1.5977 | 2.4827 | 0.0000 |
| MDRG\_541 | 41,385 | 0.3840 | 0.0897 | 0.6782 | 0.0105 |
| MDRG\_542 | 30,023 | 0.8745 | 0.6098 | 1.1392 | 0.0000 |
| MDRG\_601 | 65,150 | 1.6232 | 1.4899 | 1.7566 | 0.0000 |
| MDRG\_602 | 231,316 | 1.7317 | 1.6360 | 1.8273 | 0.0000 |
| MDRG\_605 | 13,157 | -2.4084 | -4.3978 | -0.4190 | 0.0177 |
| MDRG\_607 | 10,897 | 0.4344 | -0.0831 | 0.9520 | 0.1000 |
| MDRG\_610 | 35,776 | -1.4627 | -2.2129 | -0.7125 | 0.0001 |
| MDRG\_613 | 18,640 | -1.5312 | -2.5376 | -0.5248 | 0.0029 |
| MDRG\_614 | 30,969 | -1.5540 | -2.3313 | -0.7767 | 0.0001 |
| MDRG\_615 | 311,273 | -2.2181 | -2.5852 | -1.8509 | 0.0000 |
| MDRG\_616 | 23,842 | -1.3319 | -2.1383 | -0.5256 | 0.0012 |
| MDRG\_619 | 41,642 | -2.6016 | -3.8071 | -1.3962 | 0.0000 |
| MDRG\_620 | 93,093 | -1.8297 | -2.3596 | -1.2997 | 0.0000 |
| MDRG\_621 | 70,401 | -1.8789 | -2.5111 | -1.2467 | 0.0000 |
| MDRG\_701 | 20,891 | 1.2081 | 0.9443 | 1.4720 | 0.0000 |
| MDRG\_702 | 6,078 | 2.4417 | 2.1737 | 2.7098 | 0.0000 |
| MDRG\_704 | 13,320 | 1.8637 | 1.6187 | 2.1088 | 0.0000 |
| MDRG\_705 | 103,193 | 0.5204 | 0.3433 | 0.6974 | 0.0000 |
| MDRG\_708 | 34,566 | -2.8686 | -4.3127 | -1.4246 | 0.0001 |
| MDRG\_710 | 19,913 | -2.9964 | -5.1517 | -0.8412 | 0.0064 |
| MDRG\_711 | 26,654 | -2.2493 | -3.4562 | -1.0424 | 0.0003 |
| MDRG\_801 | 30,343 | 0.4185 | 0.0912 | 0.7458 | 0.0122 |
| MDRG\_803 | 55,551 | -0.6756 | -1.0999 | -0.2513 | 0.0018 |
| MDRG\_815 | 17,712 | -2.7427 | -4.9479 | -0.5375 | 0.0148 |
| MDRG\_1102 | 14,466 | 2.0538 | 1.8100 | 2.2976 | 0.0000 |
| MDRG\_1103 | 32,060 | 0.7625 | 0.4822 | 1.0429 | 0.0000 |
| MDRG\_1104 | 26,574 | 1.0276 | 0.7680 | 1.2871 | 0.0000 |
| MDRG\_1110 | 50,272 | -3.9037 | -5.8841 | -1.9233 | 0.0001 |
| MDRG\_1113 | 30,304 | -1.6999 | -2.5830 | -0.8169 | 0.0002 |
| MDRG\_1118 | 43,452 | -2.6562 | -3.8992 | -1.4132 | 0.0000 |
| MDRG\_1303 | 9,671 | 1.0518 | 0.5937 | 1.5099 | 0.0000 |
| MDRG\_1304 | 23,044 | 0.9532 | 0.6453 | 1.2612 | 0.0000 |
| MDRG\_1604 | 46,069 | -2.3724 | -3.3485 | -1.3963 | 0.0000 |
| MDRG\_1709 | 3,673 | 1.6246 | 1.1338 | 2.1154 | 0.0000 |
| MDRG\_1801 | 101,219 | 1.0191 | 0.8799 | 1.1583 | 0.0000 |
| MDRG\_1802 | 8,316 | 1.1147 | 0.7157 | 1.5136 | 0.0000 |
| MDRG\_1807 | 15,826 | -0.9865 | -1.7563 | -0.2167 | 0.0120 |
| MDRG\_1808 | 171,265 | -2.0320 | -2.4483 | -1.6157 | 0.0000 |
| MDRG\_2104 | 15,677 | 1.2842 | 0.9942 | 1.5741 | 0.0000 |
| TRNSFER | 224,269 | 0.2818 | 0.1678 | 0.3957 | 0.0000 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019. The final model is analysis of Medicare FFS discharges from IPPS hospitals July 1, 2016, through June 30, 2018, processed through the CMS v10.0 PSI software.*

*Abbreviations: MDC – Major Diagnostic Category; MDRG – Modified Medicare Severity-Diagnosis Related Group*

**2b3.2. If an outcome or resource use component measure is not risk adjusted or stratified, provide rationale and analyses to demonstrate that controlling for differences in patient characteristics (case mix) is not needed to achieve fair comparisons across measured entities**.

Not applicable

**2b3.3a. Describe the conceptual/clinical and statistical methods and criteria used to select patient factors (clinical factors or social risk factors) used in the statistical risk model or for stratification by risk** (*e.g., potential factors identified in the literature and/or expert panel; regression analysis; statistical significance of p<0.10; correlation of x or higher; patient factors should be present at the start of care*) **Also discuss any “ordering” of risk factor inclusion;** for example, are social risk factors added after all clinical factors?

The conceptual approach to PSI risk-adjustment includes age and gender as key demographic characteristics, the reason(s) why the patient was admitted to the hospital, the type of operating room procedure(s) that the patient received (for postprocedural events), comorbid conditions that are associated with clinically significant disabilities or increase the risk of adverse events, and transfer-in as an indicator of recent health service use at a different facility. Because the PSIs focus on adverse events occurring within acute care hospitals, often after a major operating room procedure, social risk factors are not included in the conceptual approach.

Through testing and refinement over the past decade, these risk factor concepts are now operationalized using open-source tools, as follows:

* Age categories, generally 5 years in width, using the youngest category as the omitted referent. (Five year categories have been shown to work better, in general, than either wider categories or linear/quadratic specifications.)
* Sex categories, using female as the omitted referent.
* Two-way age-sex interactions, which allow for different age-outcome relationships among men versus women. (Older men often show lower risk than older women, presumably due to “healthy survivor” or “surgical selection” effects.)
* AHRQ (Elixhauser) comorbidities, which are coded using publicly available HCUP software, annually updated, and extensively validated.[[13]](#footnote-14) (Comorbidities are identified using only ICD-10-CM diagnoses reported as present on admission, including “clinically undetermined” diagnoses and codes classified as POA-exempt.)
* Major Diagnostic Categories (MDCs) based on the body system of the principal diagnosis[[14]](#footnote-15)
* Modified Diagnosis Related Groups (MDRGs) based on aggregation of adjacent Medicare Severity (MS) DRGs with or without comorbidities and complications, which capture both the reason for admission and major operating procedures, without adjusting for hospital-associated complications.[[15]](#footnote-16) (Certain MS-DRGs are omitted from feature selection because they capture complications of hospital care – 003, 004, 011, 012, or 013 for ECMO or tracheostomy – or because they are clinically uninterpretable – 981-989 for OR procedures unrelated to the principal diagnosis, 998 for invalid principal diagnosis, and 999 for ungroupable.)
* Point of origin indicating transfer in from another hospital.

CMS starts de novo with the full set of available risk factors and performs risk factor selection methods to develop risk-adjustment models. In particular, after filtering out risk factors that have small denominators (e.g., fewer than 30 records), and that have quasi completeness or high collinearity, (e.g., Variance Inflation Factor of 1000 or higher), the least absolute shrinkage and selection operator (LASSO) feature selection method, a penalized regression approach, is used to select risk factors that provide good balance between model performance and model complexity. The LASSO method is used because the traditional p-value or stepwise based selection methods use sequential fitting, which could lead to biased coefficient estimates and less optimal models. Generalized estimating equations (GEE) with the logit-binomial link function are used to address the clustering of patients within hospitals.

The exceptions to this method are PSI 11 (Postoperative Respiratory Failure Rate) and PSI 13 (Postoperative Sepsis Rate). After fitting the PSI 11 and PSI 13 risk-adjustment models using GEE, the resulting model fit was poor particularly for discharges at the lowest risk of a PSI event. In an effort to improve model fit, the PSI 11 and PSI 13 risk-adjustment models were refit with ordinary logistic regression on the same risk factors. The C statistics for the overall model are similar using the logistic regression model compared with the GEE model with logit-binomial link function; however, model calibration is substantially improved for discharges at the lowest risk of a PSI event.

# 2b3.3b. How was the conceptual model of how social risk impacts this outcome developed? Please check all that apply:

**Published literature**

* + **Internal data analysis**
  + **Other (please describe)**

In general, any observed relationship between social or sociodemographic status (SDS) factors and PSI events could work through three mechanisms:

1. Patients with social risk factors may have worse health at the time of hospital admission (in ways that cannot be captured through other measured variables, such as comorbidities, diagnoses, and procedures or services used).
2. Patients with social risk factors may receive care at lower-quality hospitals.
3. Patients with social risk factors may receive poorer care within hospitals, even accounting for their severity of illness and their distribution across hospitals.

The second and third mechanisms have been extensively studied and validated in the peer-reviewed literature as well as research reported by the Office of the Assistant Secretary for Planing and Evaluation (ASPE) pursuant to the IMPACT Act of 2014.

Therefore, CMS follows ASPE guidance, as summarized in its March 2020 *Report to Congress on Social Risk Factors and Performance in Medicare’s Value-Based Purchasing Program*: “Recommendation 1.6: Composite scores should not be adjusted for social risk factors for public reporting. Composite measures used for public reporting should NOT use measures that are adjusted for public reporting. They should also not use other methods to account for social risk, such as peer grouping.” In the case of PSI 90, these recommendations are generally consistent with guidance contained in the *NQF Technical Report on Risk-Adjustment for Socioeconomic Status or Other Sociodemographic Factors* (August 15, 2014): “For example, the outcome of central line infection occurring during a hospital stay would not have a conceptual basis for SDS adjustment, as thre is no logical reason why these measures should be affected by variables such as poverty, illiteracy, or limited English proficiency. Important considerations include whether the key processes leading to an outcome are directly under the control of the healthcare unit and do not depend on active patient participation as in the examples noted above.” Specifically, based on NQF’s suggested questions for identifying a conceptual basis for adjusting for sociodemographic factors (p. 36):

* Prior research does not indicate a consistent relationship between SDS and PSI outcomes.
* There is no clear theory supporting a relationship between SDS and PSI outcomes.
* There is no passage of time between the hospital’s treatment and PSI outcomes, during which other factors may have an effect.
* Patient actions or decisions affected by SDS do not consistently influence PSI outcomes (e.g., ability to purchase medications).
* The patient community outside the hospital has no clear influence on PSI outcomes (e.g., distance to pharmacies, groceries, other resources).

CMS continues to explore ways to improve the PSI risk-adjustment models to include additional measures of risk that are correlated with social risk factors, consistent with ASPE recommendations, including functional risk and prior health service use. For example, a variable indicating transfer-in from another hospital has been added to all risk-adjustment models. Variables indicating transfer-in from skilled nursing care, assisted living facilities, and hospice care (as measures of functional risk) are currently being tested, and will be added to the next version of the CMS Medicare PSI software if appropriate.

**2b3.4a. What were the statistical results of the analyses used to select risk factors?**

Please refer to detailed model results above; the table below summarizes the results of feature selection for PSI risk-adjustment models. HCUP results are shown with Medicare FFS results to demonstrate the robustness of the approach across data sources, given that previous NQF endorsement was based on HCUP all-payer data.

**Table 17. Number of Covariates Selected for PSI Risk-Adjustment Models in CMS v10.0 (Current), CMS v9.0, and AHRQ v2019**

| **PSIs** | **CMS Medicare FFS Data (CMS v10.0)** | **CMS Medicare FFS Data (CMS v9.0)** | **HCUP All-Payer Data (v2019)** |
| --- | --- | --- | --- |
| **PSI 03** | 138 | 135 | 147 |
| **PSI 06** | 127 | 94 | 125 |
| **PSI 08** | 131 | 130 | 116 |
| **PSI 09** | 95 | 98 | 113 |
| **PSI 10** | 77 | 88 | 91 |
| **PSI 11** | 70 | 72 | 86 |
| **PSI 12** | 125 | 113 | 124 |
| **PSI 13** | 82 | 83 | 92 |
| **PSI 14A** | NA | 67 | 79 |
| **PSI 14B** | NA | 49 | 23 |
| **PSI 15** | 132 | 93 | 103 |

*Source: CVP/Mathematica Scientific Acceptability Report, December 2019; AHRQ v2019 PSI Parameter Estimates*

*Note:* *PSI 14A reflects postoperative wound dehiscence with an open approach and PSI 14B reflects non-open approach.*

**2b3.4b. Describe the analyses and interpretation resulting in the decision to select social risk factors** (e.g. prevalence of the factor across measured entities, empirical association with the outcome, contribution of unique variation in the outcome, assessment of between-unit effects and within-unit effects.) Also describe the impact of adjusting for social risk (or not) on providers at high or low extremes of risk.

Not applicable; see 2b3.3b above.

**2b3.5. Describe the method of testing/analysis used to develop and validate the adequacy of the statistical model or stratification approach** (*describe the steps―do not just name a method; what statistical analysis was used*)

For each PSI, we summarize model fit and adequacy using the following measures:

* Overall model discrimination as assessed by C-statistic. We calculated C-statistics using Medicare FFS data to determine the predicted probability from the CMS v10.0 model developed on the July 2016–June 2018 Medicare FFS reference population. The C-statistic is the area under the receiver-operator curve that measures the discriminative ability of a regression model. It also describes the probability that a randomly selected patient who experienced a PSI event had a higher expected value than a randomly selected patient who did not experience that event.
* Model fit by deciles of patient risk using Hosmer-Lemeshow plots. The Hosmer-Lemeshow plots show the observed-to-predicted ratio for deciles of risk with July 2016–June 2018 Medicare FFS data processed through CMS v10.0 models. For each PSI, the deciles of risk are ten mutually exclusive groups containing an equal number discharges, ranging from very low-risk patients (according to the model) to high-risk patients. We do not provide Hosmer-Lemeshow test statistics because, given the large sample size of our data, the null hypothesis is almost always rejected. Moreover, the plots provide more detail on model fit than the overall Hosmer-Lemeshow statistic.

*Provide the statistical results from testing the approach to controlling for differences in patient characteristics (case mix) below*.

## If stratified, skip to [2b3.9](#_bookmark7)

**2b3.6. Statistical Risk Model Discrimination Statistics** (*e.g., c-statistic, R-squared*)**:**

HCUP results are shown with Medicare FFS results to demonstrate the robustness of the approach across data sources, given that previous NQF endorsement was based on HCUP all-payer data.

**Table 18. Discrimination of PSI Risk-Adjustment Models in CMS v10.0 (Current), CMS v9.0, and AHRQ v2019**

| **PSIs** | **CMS Medicare FFS Data (v10.0) C-statistic** | **CMS Medicare FFS Data (v9.0) C-statistic** | **HCUP All-Payer Data (v2019) C-statistic** |
| --- | --- | --- | --- |
| PSI 03 | 0.814 | 0.812 | 0.809 |
| PSI 06 | 0.852 | 0.852 | 0.847 |
| PSI 08 | 0.871 | 0.852 | 0.861 |
| PSI 09 | 0.791 | 0.799 | 0.771 |
| PSI 10 | 0.902 | 0.907 | 0.906 |
| PSI 11 | 0.828 | 0.825 | 0.825 |
| PSI 12 | 0.711 | 0.712 | 0.740 |
| PSI 13 | 0.847 | 0.843 | 0.847 |
| PSI 14A | 0.777 | NA | 0.805 |
| PSI 14B | 0.889 | NA | 0.774 |
| PSI 15 | 0.902 | 0.907 | 0.779 |

*Source: CVP/Mathematica Scientific Acceptability Report, December 2019; AHRQ v2019 PSI Parameter Estimates*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

*C-statistics indicate the area under the receiver-operator curve that measures the discriminative capacity of a regression model.*

*Risk-adjustment for PSI 14 was done at the individual component level for CMS v10.0 and the overall level for CMS v9.0, resulting in NA values for PSI 14A and PSI 14B.*

**2b3.7. Statistical Risk Model Calibration Statistics** (*e.g., Hosmer-Lemeshow statistic*):

Due to the very large sample sizes used to test these measures, all Hosmer-Lemeshow chi square statistics are significant (p<0.05) and uninformative. Therefore, we rely on risk decile plots as shown below (Figures 2-12).

**2b3.8. Statistical Risk Model Calibration – Risk decile plots or calibration curves**:

**Table 19. Number and Rate (per 1000) of PSI 90 Component Numerator Events in Each Predicted Risk Decile**

| **Predicted Risk Decile** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PSI 03 N** | 53 | 130 | 191 | 241 | 299 | 391 | 536 | 765 | 1,374 | 4,146 |
| **PSI 03 Rate** | 0.039 | 0.096 | 0.142 | 0.179 | 0.222 | 0.290 | 0.398 | 0.568 | 1.019 | 3.076 |
| **PSI 06 N** | 21 | 45 | 86 | 115 | 156 | 196 | 260 | 341 | 420 | 2,781 |
| **PSI 06 Rate** | 0.012 | 0.026 | 0.049 | 0.066 | 0.089 | 0.112 | 0.149 | 0.195 | 0.241 | 1.594 |
| **PSI 08 N** | 5 | 10 | 20 | 29 | 39 | 49 | 80 | 96 | 276 | 1,056 |
| **PSI 08 Rate** | 0.003 | 0.007 | 0.013 | 0.019 | 0.025 | 0.032 | 0.052 | 0.063 | 0.180 | 0.689 |
| **PSI 09 N** | 41 | 45 | 92 | 346 | 532 | 996 | 1,270 | 1,535 | 2,330 | 4,457 |
| **PSI 09 Rate** | 0.088 | 0.096 | 0.197 | 0.740 | 1.138 | 2.131 | 2.718 | 3.285 | 4.986 | 9.538 |
| **PSI 10 N** | 3 | 4 | 11 | 14 | 28 | 70 | 163 | 281 | 535 | 2,420 |
| **PSI 10 Rate** | 0.012 | 0.015 | 0.042 | 0.054 | 0.108 | 0.269 | 0.627 | 1.080 | 2.057 | 9.303 |
| **PSI 11 N** | 72 | 135 | 181 | 295 | 451 | 613 | 847 | 1,431 | 2,310 | 6,619 |
| **PSI 11 Rate** | 0.342 | 0.641 | 0.860 | 1.401 | 2.142 | 2.912 | 4.023 | 6.797 | 10.972 | 31.439 |
| **PSI 12 N** | 333 | 608 | 955 | 961 | 1,186 | 1,544 | 1,811 | 2,331 | 3,221 | 5,838 |
| **PSI 12 Rate** | 0.666 | 1.217 | 1.911 | 1.923 | 2.374 | 3.090 | 3.625 | 4.665 | 6.447 | 11.684 |
| **PSI 13 N** | 76 | 78 | 119 | 176 | 336 | 480 | 748 | 1,299 | 2,263 | 6,567 |
| **PSI 13 Rate** | 0.300 | 0.307 | 0.469 | 0.694 | 1.324 | 1.892 | 2.948 | 5.119 | 8.918 | 25.880 |
| **PSI 14A N** | 4 | 5 | 23 | 31 | 51 | 67 | 99 | 134 | 211 | 339 |
| **PSI 14A Rate** | 0.076 | 0.094 | 0.434 | 0.585 | 0.963 | 1.265 | 1.870 | 2.531 | 3.985 | 6.402 |
| **PSI 14B N** | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 4 | 5 | 24 |
| **PSI 14B Rate** | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.018 | 0.018 | 0.071 | 0.089 | 0.425 |
| **PSI 15 N** | 16 | 23 | 45 | 74 | 153 | 235 | 329 | 443 | 830 | 1,762 |
| **PSI 15 Rate** | 0.052 | 0.074 | 0.145 | 0.239 | 0.494 | 0.759 | 1.062 | 1.430 | 2.679 | 5.687 |

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*PSI 14A reflects postoperative wound dehiscence with an open approach and PSI 14B reflects non-open approach.*

**Figure 2. PSI 03 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 03 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The model shows some deviation from an observed-to-expected ratio close to 1.0, but this variation is generally in the lowest risk deciles, which include less than 1% of all events, meaning that calibration error is limtied to the portion of the risk distribution in which events are extremely rare. 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 3. PSI 06 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 06 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The model shows some deviation from an observed-to-expected ratio close to 1.0, but this variation is generally in the lowest risk deciles, which include less than 1% of all events, meaning that calibration error is limtied to the portion of the risk distribution in which events are extremely rare. 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 4. PSI 08 Hosmer-Lemeshow plot**

Hosmer-Lemeshow plot for PSI 08 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The figure shows excellent model calibration, with observed-to-expeced ratios close to 1.0 across all deciles, especially for the current version (v10.0) as compared with the previous version (v9.0). 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 5. PSI 09 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 09 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The figure shows excellent model calibration, with observed-to-expeced ratios close to 1.0 across all deciles, especially for the current version (v10.0) as compared with the previous version (v9.0). 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software..*

**Figure 6. PSI 10 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 10 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The model shows some deviation from an observed-to-expected ratio close to 1.0, but this variation is generally in the lowest risk deciles, which include less than 1% of all events, meaning that calibration error is limtied to the portion of the risk distribution in which events are extremely rare. 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 7. PSI 11 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 11 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The model shows some deviation from an observed-to-expected ratio close to 1.0, but this variation is generally in the lowest risk deciles, which include less than 1% of all events, meaning that calibration error is limtied to the portion of the risk distribution in which events are extremely rare.

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 8. PSI 12 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 12 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The figure shows excellent model calibration, with observed-to-expeced ratios close to 1.0 across all deciles, especially for the current version (v10.0) as compared with the previous version (v9.0). 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 9. PSI 13 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 13 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The model shows some deviation from an observed-to-expected ratio close to 1.0, but this variation is generally in the lowest risk deciles, which include less than 1% of all events, meaning that calibration error is limtied to the portion of the risk distribution in which events are extremely rare. 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 10. PSI 14A Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 14A processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The figure shows excellent model calibration, with observed-to-expeced ratios close to 1.0 across all deciles, especially for the current version (v10.0) as compared with the previous version (v9.0). 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 11. PSI 14B Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 14B processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The figure shows excellent model calibration, with observed-to-expeced ratios close to 1.0 across all deciles, especially for the current version (v10.0) as compared with the previous version (v9.0). 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**Figure 12. PSI 15 Hosmer-Lemeshow plot** Hosmer-Lemeshow plot for PSI 15 processed with both v9.0 and v10.0 CMS software. The figure displays the observed-to-expected ratio (Y axis) and the predicted risk decile (X axis). 
The figure shows excellent model calibration, with observed-to-expeced ratios close to 1.0 across all deciles, especially for the current version (v10.0) as compared with the previous version (v9.0). 

*Source: CVP/Mathematica Risk-Adjustment Report, October 2019*

*Note: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with v10.0 CMS software.*

*CMS v9.0 represents analysis of the same discharges processed through CMS v9.0 software.*

**2b3.9. Results of Risk Stratification Analysis**:

Not applicable

**2b3.10. What is your interpretation of the results in terms of demonstrating adequacy of controlling for differences in patient characteristics (case mix)?** (i*.e., what do the results mean and what are the norms for the test conducted*)

The c statistic is a measure of the extent to which a statistical model is able to discriminate between patients with and without the outcome, equivalent to the area under a receiver operating characteristic (ROC) curve. The c statistic ranges between 0.5 for a model that is no better than random prediction to 1.0 for a model with perfect prediction, in which outcomes are fully explained by patient characteristics and quality-of-care plays no role. As shown in **Table 18**, PSI risk-adjustment models are very strong, with discrimination (c) statistics over 0.75 except for PSI 12 (c=0.71). In general, c-statistics >0.75 are considered excellent for these types of risk-adjustment models. As shown in **Table 19**, these models also sort patients very well based on their risk, with 18-fold (11.684/0.666, PSI 12) to 807-fold (9.303/0.012, PSI 10) differences in risk between the decile of lowest risk patients and the decile of highest risk patients. Finally, **Figures 2-12** show excellent model calibration, with observed-to-expected ratios close to 1.0 across nearly all deciles, especially for the current version 10.0 (in comparison with the previous version 9.0). Where significant deviations from 1.0 exist, as in **Figures 2, 3, 6, 7, and 9**, they are generally in the lowest risk deciles, which include less than 1% of all events. In other words, calibration error is limited to the portion of the risk distribution in which events are extremely rare.

**2b3.11. Optional Additional Testing for Risk Adjustment** (*not required, but would provide additional support of adequacy of risk model, e.g., testing of risk model in another data set; sensitivity analysis for missing data; other methods that were assessed*)

All risk models have been tested and recalibrated using both Medicare FFS data and all-payer HCUP data; see results in **Tables 17-18** above. The results of feature selection, model discrimination, and model calibration are generally very consistent between the two data sources.

# 2b4. IDENTIFICATION OF STATISTICALLY SIGNIFICANT & MEANINGFUL DIFFERENCES IN PERFORMANCE

***Note:*** *Applies to the composite performance measure.*

**2b4.1. Describe the method for determining if statistically significant and clinically/practically meaningful differences in performance measure scores among the measured entities can be identified** (*describe the steps―do not just name a method; what statistical analysis was used? Do not just repeat the information provided related to performance gap in 1b)*

First, the distribution of CMS Medicare PSI 90 scores was tabulated across hospitals to examine the magnitude of relative differences in performance. The mean, standard deviation, 5th, 25th, 50th, 75th, and 95th percentiles are shown in **Table 20**. The interquartile range represents the difference between the 25th and 75th percentiles.

Second, 95% confidence intervals are computed around each hospital’s estimated CMS Medicare PSI 90 score, based on the square root of its estimated variance. The estimated variance is computed based on the signal variance-covariance matrix in the reference population and the hospital’s own reliability weights. This calculation is based on the assumption of independence among the component PSIs – that is, component PSI rates are uncorrelated within hospitals. Hospitals for which the 95% confidence interval does not include 1 (the value based on the national reference population) are classified as outliers. The CMS Medicare PSI 90 score values for these outliers are shown in **Table 21** and graphically displayed in **Figure 13**.

**2b4.2. What were the statistical results from testing the ability to identify statistically significant and/or clinically/practically meaningful differences in performance measure scores across measured entities?** (e.g., *number and percentage of entities with scores that were statistically significantly different from mean or some benchmark, different from expected; how was meaningful difference defined*)

**Table 20. Distribution of Hospital Performance on PSI 90 across Three Time Periods Used for Reporting**

| **Years** | **N** | **Mean score** | **SD** | **5th percentile** | **25th percentile** | **Median score** | **75th percentile** | **95th percentile** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2016-17 | 3305 | 0.995 | 0.173 | 0.805 | 0.908 | 0.972 | 1.035 | 1.288 |
| 2017-18 | 3287 | 0.995 | 0.165 | 0.808 | 0.908 | 0.971 | 1.028 | 1.287 |
| 2018-19 | 3249 | 0.996 | 0.16 | 0.804 | 0.913 | 0.972 | 1.031 | 1.276 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with CMS v10.0 software.  
Abbreviations: SD=standard deviation; p=percentile*

**Table 21. Descriptive Statistics for PSI 90 Scores across Statistically Determined Hospital Outlier Groups**

| **Outlier Group** | **Number of Hospitals (%)** | **Mean** | **Minimum** | **25th percentile** | **Median** | **75th percentile** | **Maximum** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| High performing | 103 (3.1%) | 0.71 | 0.41 | 0.68 | 0.71 | 0.75 | 0.87 |
| Neither | 3031 (90.6%) | 0.97 | 0.64 | 0.89 | 0.96 | 1.02 | 1.40 |
| Low performing | 211 (6.3%) | 1.48 | 1.14 | 1.32 | 1.40 | 1.54 | 4.58 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2019) processed with CMS v10.0 software.*

**Figure 13. Distribution of PSI 90 Scores across Statistically Determined Hospital Outlier Groups**

This figure displays the distribution of PSI 90 scores across statistically determined hospital outlier goups. The figure shows that when the PSI 90 score is less than about 0.5 or more than about 1.3, the majority of hospitals can be identified as statistical outliers (because the histogram for the outlier group surpasses the histogram for the nonoutlier group).

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2016-6/30/2018) processed with CMS v10.0 software.*

*Note: hospital counts along the Y axis*

**2b4.3. What is your interpretation of the results in terms of demonstrating the ability to identify statistically significant and/or clinically/practically meaningful differences in performance across measured entities?** (i*.e., what do the results mean in terms of statistical and meaningful differences?*)

Statistically significant and practically/clinically meaningful differences in performance can be identified. Although the interquartile range in **Table 20** indicates only 13-14% relative difference in PSI 90 scores between the 25th and 75th percentiles (e.g., 1.035/0.908), this finding reflects removal of confounding effects through risk-adjustment and removal of noise through reliability-adjustment. The relative difference between the 5th and 95th percentiles in **Table 20** (e.g., 1.288/0.805) is 58-60%, which represents a substantial difference in the incidence of clinically important complications (after both risk-adjustment and reliability-adjustment). As shown in **Table 21**, PSI 90 identifies about 10% of hospitals (e.g., 314/3145) as performance outliers, using 24 months of Medicare FFS claims data. High-performing outliers have PSI 90 scores of 0.41 to 0.87 (median 0.71, IQR 0.68-0.75), indicating substantially fewer complications than expected from the reference population. Low-performing outliers have PSI 90 scores of 1.14 to 4.58 (median 1.40, IQR 1.32-1.54), indicating substantially more complications than expected from the reference population. **Figure 13** shows that when the PSI 90 score is less than about 0.5 or more than about 1.3, the majority of hospitals can be identified as statistical outliers (because the histogram for the outlier group surpasses the histogram for the nonoutlier group).

# 2b5. COMPARABILITY OF PERFORMANCE SCORES WHEN MORE THAN ONE SET OF SPECIFICATIONS

***Note:*** *Applies to all component measures, unless already endorsed or are being submitted for individual endorsement.*

## If only one set of specifications, this section can be skipped.

**Note***: This item is directed to measures that are risk-adjusted (with or without social risk factors)* ***OR*** *to measures with more than one set of specifications/instructions (e.g., one set of specifications for how to identify and compute the measure from medical record abstraction and a different set of specifications for claims or eMeasures). It does not apply to measures that use more than one source of data in one set of specifications/instructions (e.g., claims data to identify the denominator and medical record abstraction for the numerator).* ***Comparability is not required when comparing performance scores with and without social risk factors in the risk adjustment model. However, if comparability is not demonstrated for measures with more than one set of specifications/instructions, the different specifications (e.g., for medical records vs. claims) should be submitted as separate measures.***

**2b5.1. Describe the method of testing conducted to compare performance scores for the same entities across the different data sources/specifications** (*describe the steps―do not just name a method; what statistical analysis was used*)

Not applicable

# 2b5.2. What were the statistical results from testing comparability of performance scores for the same entities when using different data sources/specifications? (*e.g., correlation, rank order*)

Not applicable

**2b5.3. What is your interpretation of the results in terms of the differences in performance measure scores for the same entities across the different data sources/specifications?** (i*.e., what do the results mean and what are the norms for the test conducted?*)

Not applicable

# 2b6. MISSING DATA ANALYSIS AND MINIMIZING BIAS

***Note:*** *Applies to the overall composite measure.*

**2b6.1. Describe the method of testing conducted to identify the extent and distribution of missing data (or nonresponse) and demonstrate that performance results are not biased** due to systematic missing data (or differences between responders and nonresponders) and how the specified handling of missing data minimizes bias (*describe the steps―do not just name a method; what statistical analysis was used*)

For a claims-based measure such as PSI 90, a discharge may be missing a key data element (for example, present-on-admission codes); claims may be missing from the analytic file; or measure results may be missing from certain hospitals that do not have sufficient numbers of denominator-eligible cases. In general, Medicare claims are essentially 100% complete on all of the necessary data elements because payment is contingent on submission of a complete claim. Therefore, we focused on hospitals that do not have PSI 90 component values. When a hospital has fewer than three denominator cases, the CMS Medicare PSI software substitutes the component indicator value with the observed-to-expected ratio in the reference population (1.0) to construct the PSI 90 composite. Although it happens infrequently, a hospital can receive a CMS Medicare PSI 90 composite value if one to ten of the 10 components are imputed using the observed-to-expected ratio in the reference population (i.e., 1.0). We examined the number of components missing from the PSI 90 composite for each hospital and the proportion of hospitals missing combinations of component indicators.

**2b6.2. What is the overall frequency of missing data, the distribution of missing data across providers, and the results from testing related to missing data?** (*e.g., results of sensitivity analysis of the effect of various rules for missing data/nonresponse; if no empirical sensitivity analysis, identify the approaches for handling missing data that were considered and pros and cons of each*)

**Table 22. Number and Percentage of Hospitals with Missing PSI 90 Component Indicators, by Number of Missing Components, with Mean Imputed PSI 90 Scores**

| **Number of missing PSI components** | **Number of hospitals** | **Percentage of hospitals** | **Mean PSI 90 composite value** | **Standard Deviation** |
| --- | --- | --- | --- | --- |
| 0 | 2,947 | 89.0% | 0.992 | 0.202 |
| 1 | 31 | 0.9% | 0.976 | 0.076 |
| 2 | 24 | 0.7% | 0.970 | 0.064 |
| 3 | 101 | 3.0% | 0.972 | 0.113 |
| 4 | 24 | 0.7% | 0.992 | 0.059 |
| 5 | 6 | 0.2% | 0.992 | 0.005 |
| 6 | 45 | 1.4% | 1.018 | 0.224 |
| 7 | 119 | 3.6% | 0.990 | 0.027 |
| 8 | 8 | 0.2% | 1.000 | 0.000 |
| 10 | 8 | 0.2% | 1.000 | 0.000 |

*Source: CVP/Mathematica Scientific Acceptability Report, December 2019*

*Medicare FFS discharges from 3,313 IPPS hospitals, July 1, 2016, through June 30, 2018 processed with CMS v10.0 PSI software.*

**2b6.3. What is your interpretation of the results in terms of demonstrating that performance results are not biased** due to systematic missing data (or differences between responders and nonresponders) and how the specified handling of missing data minimizes bias**?** (i*.e., what do the results mean in terms of supporting the selected approach for missing data and what are the norms for the test conducted; if no empirical analysis, provide rationale for the selected approach for missing data*)

Missing data are extremely uncommon (<0.01%) at the component measure level, so they cannot have any meaningful impact on PSI 90 scores. Missing component measures are more common, affecting about 11% of eligible hospitals, as shown in **Table 23**. Eight hospitals are missing all 10 components, and another 8 are missing 8 or 9 components. The majority (89%) of hospitals, as shown in **Table 23**, have all 10 PSI components contributing to PSI 90. These hospitals have a composite value of 0.992, slightly better than the national average, 1.000. Three percent of hospitals have the national observed-to-expected ratio substituted for three PSIs in the composite calculation. These hospitals have a slightly better-than-average composite value, 0.972. For accountability applications, users are encouraged to set a minimum threshold for the allowable number of PSI 90 component measures. CMS is considering suppressing public reporting for hospitals with 4 or more missing component measures, as 7 non-missing component measures are sufficient to estimate about half of the total weight of PSI 90.

# 2c. EMPIRICAL ANALYSIS TO SUPPORT COMPOSITE CONSTRUCTION APPROACH

***Note:*** *If empirical analyses do not provide adequate results—or are not conducted—justification must be provided and accepted in order to meet the must-pass criterion of Scientific Acceptability of Measure Properties. Each of the following questions has instructions if there is no empirical analysis.*

# 2d1. Empirical analysis demonstrating that the component measures fit the quality construct, add value to the overall composite, and achieve the object of parsimony to the extent possible.

**2d1.1 Describe the method used** (*describe the steps―do not just name a method; what statistical*

*analysis was used; if no empirical analysis, provide justification)*

We computed weighted Pearson and Spearman (rank) correlations between hospitals’ PSI 90 scores and each of their component smoothed risk-adjusted rates (RAR). These correlations are equal to the correlations with the corresponding smoothed observed/expected ratios because the RAR is a constant multiple of the observed/expected ratio within each PSI. The weighted Pearson correlation uses the PSI denominator for a weight.

We also computed Spearman rank correlations among all of the component indicators, after risk-adjustment and smoothing. One tenet of this composite is that each component measure is correlated with an aspect of each hospital’s underlying quality of care. Therefore, we expect to observe positive hospital-level correlations among the individual measures within the composite.

**2d1.2. What were the statistical results obtained from the analysis of the components?** (e.g., *correlations, contribution of each component to the composite score, etc*.; *if no empirical analysis, identify the components that were considered and the pros and cons of each*)

**Table 23. PSI 90 Component Weights, by Version, and Item-Total Spearman Rank Correlations**

| **PSIs** | **CMS v9.0 weight** | **CMS v10.0 weight** | **CMS v10.0 Item-Total Correlation (2016-2018)** |
| --- | --- | --- | --- |
| PSI 03 | 0.134 | 0.161 | 0.659 |
| PSI 06 | 0.041 | 0.039 | 0.172 |
| PSI 08 | 0.015 | 0.015 | 0.046 |
| PSI 09 | 0.042 | 0.043 | 0.160 |
| PSI 10 | 0.078 | 0.081 | 0.232 |
| PSI 11 | 0.212 | 0.185 | 0.522 |
| PSI 12 | 0.185 | 0.188 | 0.494 |
| PSI 13 | 0.247 | 0.242 | 0.472 |
| PSI 14 | 0.009 | 0.009 | 0.038 |
| PSI 15 | 0.037 | 0.037 | 0.216 |

*Source: First two columns are from the CVP/Mathematica Scientific Acceptability Report, December 2019.*

*Note: Results based on CMS v10.0 PSI software with parameters derived from Medicare FFS discharges from 3,313 IPPS hospitals, 7/1/2016-6/30/2018. CMS v9.0 weights were derived using data from 7/1/2015-6/30/2017.*

**Table 24. Spearman Rank Correlation Between PSI 90 Composite Score and Each of the PSI Components’ Smoothed Risk-Adjusted Rate**

| **Correlation** | **PSI 03** | **PSI 06** | **PSI 08** | **PSI 09** | **PSI 10** | **PSI 11** | **PSI 12** | **PSI 13** | **PSI 14** | **PSI 15** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Spearman Correlation | 0.6559 | 0.168 | 0.080 | 0.160 | 0.223 | 0.538 | 0.484 | 0.440 | 0.051 | 0.200 |
| N | 3,289 | 3,298 | 3,294 | 3,117 | 3,001 | 2,995 | 3,117 | 2,984 | 3,042 | 3,129 |
| Weighted Pearson Correlation | 0.7835 | 0.176 | 0.023 | 0.242 | 0.284 | 0.465 | 0.471 | 0.438 | 0.065 | 0.252 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2017-6/30/2019) processed with v10.0 CMS software*

*Note: all correlations were significant (<0.0001) with the exception of the weighted Pearson correlation for PSI 08 (p=0.1947)*

**Table 25. Spearman Rank Correlations Among Risk-Adjusted PSI 90 Component Indicators**

| **PSI** | **Corr.** | **PSI03** | **PSI06** | **PSI08** | **PSI09** | **PSI10** | **PSI11** | **PSI12** | **PSI13** | **PSI14** | **PSI15** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PSI 03 | Corr. | 1.000 | 0.302 | 0.185 | 0.245 | 0.258 | 0.232 | 0.314 | 0.256 | 0.188 | 0.279 |
| PSI 03 | N | 3289 | 3289 | 3285 | 3113 | 2997 | 2991 | 3113 | 2980 | 3041 | 3127 |
| PSI 06 | Corr. | 0.302 | 1.000 | 0.217 | 0.267 | 0.301 | 0.272 | 0.273 | 0.285 | 0.193 | 0.273 |
| PSI 06 | N | 3289 | 3298 | 3294 | 3117 | 3001 | 2995 | 3117 | 2984 | 3042 | 3129 |
| PSI 08 | Corr. | 0.184 | 0.217 | 1 | 0.139 | 0.197 | 0.109 | 0.182 | 0.162 | 0.119 | 0.177 |
| PSI 08 | N | 3285 | 3294 | 3294 | 3117 | 3001 | 2995 | 3117 | 2984 | 3042 | 3129 |
| PSI 09 | Corr. | 0.245 | 0.267 | 0.139 | 1.000 | 0.309 | 0.224 | 0.280 | 0.245 | 0.175 | 0.265 |
| PSI 09 | N | 3113 | 3117 | 3117 | 3117 | 3001 | 2995 | 3117 | 2984 | 3041 | 3089 |
| PSI 10 | Corr. | 0.258 | 0.301 | 0.197 | 0.309 | 1.000 | 0.285 | 0.239 | 0.371 | 0.262 | 0.289 |
| PSI 10 | N | 2997 | 3001 | 3001 | 3001 | 3001 | 2994 | 3001 | 2983 | 2947 | 2978 |
| PSI 11 | Corr. | 0.232 | 0.272 | 0.109 | 0.224 | 0.285 | 1.000 | 0.239 | 0.413 | 0.139 | 0.232 |
| PSI 11 | N | 2991 | 2995 | 2995 | 2995 | 2994 | 2995 | 2995 | 2981 | 2943 | 2972 |
| PSI 12 | Corr. | 0.314 | 0.273 | 0.182 | 0.280 | 0.239 | 0.239 | 1.000 | 0.277 | 0.180 | 0.245 |
| PSI 12 | N | 3113 | 3117 | 3117 | 3117 | 3001 | 2995 | 3117 | 2984 | 3041 | 3089 |
| PSI 13 | Corr. | 0.256 | 0.285 | 0.162 | 0.245 | 0.371 | 0.413 | 0.277 | 1.000 | 0.193 | 0.286 |
| PSI 13 | N | 2980 | 2984 | 2984 | 2984 | 2983 | 2981 | 2984 | 2984 | 2936 | 2963 |
| PSI 14 | Corr. | 0.188 | 0.193 | 0.119 | 0.175 | 0.262 | 0.139 | 0.180 | 0.193 | 1.000 | 0.224 |
| PSI 14 | N | 3041 | 3042 | 3042 | 3041 | 2947 | 2943 | 3041 | 2936 | 3042 | 3042 |
| PSI 15 | Corr. | 0.279 | 0.273 | 0.177 | 0.265 | 0.289 | 0.232 | 0.245 | 0.286 | 0.224 | 1.000 |
| PSI 15 | N | 3127 | 3129 | 3129 | 3089 | 2978 | 2972 | 3089 | 2963 | 3042 | 3129 |

*Source: Medicare FFS discharges from IPPS hospitals (7/1/2017-6/30/2019) processed with v10.0 CMS software*

*Abbreviations: Corr=correlation, N: number of hospitals included in that correlation analysis (based on having at least 3 denominator-eligible records)*

*Note: all correlations were statistically significant (<0.0001)*

**2d1.3. What is your interpretation of the results in terms of demonstrating that the components included in the composite are consistent with the described quality construct and add value to the overall composite?** (i*.e., what do the results mean in terms of supporting inclusion of the components; if no empirical analysis, provide rationale for the components that were selected)*

**Table 23** shows the empirically derived PSI component weights from the current software (v10.0, based on data from 7/1/2016-6/30/2018) and the previous version (v9.0, based on data from 7/1/2015-6/30/2017). The first two columns demonstrate substantial consistency in these weights over time; the increased weight on PSI 03 (Pressure Ulcer) was attributable to dropping several undesirable exclusion criteria (e.g., exclusion of patients transferred from other hospitals or long-term care facilities that developed new pressure injuries after admission). The third column shows that item-total correlations are much higher than component weights, suggesting that the composite is leveraging shared variation that exceeds what would be expected simply from the construction of the composite.

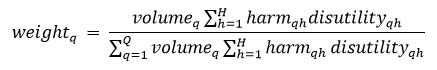
**Table 24** updates these item-total correlations with a more recent year of data (7/1/2017-6/30/2019), adding p values and weighted Pearson correlations. These hospital-level correlations vary from low (<0.1) for PSIs 08 and 14 to high (>0.4) for PSIs 03, 11, 12, and 13, but all are consistently positive. Finally, **Table 25** shows that all of the inter-item correlations among risk-adjusted PSI component measures are positive and highly significant. The highest correlation of 0.413 was between PSI 11 (Postoperative Respiratory Failure) and PSI 13 (Postoperative Sepsis), whereas the lowest correlation of 0.109 was between PSI 11 and PSI 08 (In-Hospital Hip Fracture). These findings support the design of PSI 90 as a single composite summarizing various hospital harms.

# 2d2. Empirical analysis demonstrating that the aggregations and weighting rules are consistent with the quality construct and achieve the objective of simplicity to the extent possible

**2d2.1 Describe the method used** (*describe the steps―do not just name a method; what statistical*

*analysis was used; if no empirical analysis, provide justification)*

Each component PSI indicator, q, that is part of PSI 90 receives a weight defined by:



Where:  
*Q* is the total number of component quality indicators, q, in PSI 90.

*H* is the total number of outcome types (harms), h, related to each component indicator.

*volume* is the numerator count, or the number of total QI events within the component indicator in the reference population.

*harm* is the excess risk (risk difference) of each type of outcome (i.e. harm) within each component indicator estimated from a model comparing people with PSI events to those without PSI events in an “at risk” cohort.

*disutility* is the complement of a utility weight (1-utility\_wt) assigned to each excess occurrence of each type of outcome within each component indicator.

For each component indicator in the modified version of PSI 90 composite, two sets of values need to be computed or estimated. The first is the excess risk of each harm outcome (risk difference) that may occur in association with the component PSI event. These harm risks are multiplied by harm-specific disutility scores, which reflect the relative valuation of various outcome states by patients and clinicians, and then summed across all of the harms relevant to a component PSI, to obtain the summed harm weight for each PSI. Next numerator weights are calculated from the volume (count) of each PSI component event in the CMS FFS reference population. Finally, the volume weight for each PSI is multiplied by its summed harm weight, and the resulting product is rescaled across all 10 components so that the sum of the final weights is 1.

**2d2.2. What were the statistical results obtained from the analysis of the aggregation and weighting rules?** (e.g., *results of sensitivity analysis of effect of different aggregations and/or weighting rules; if no empirical analysis, identify the aggregation and weighting rules that were considered and the pros and cons of each*)

HCUP results are shown with Medicare FFS results to demonstrate the robustness of the approach across data sources, given that previous NQF endorsement was based on HCUP all-payer data.

**Table 26. Final PSI Component Weights Reflect Both Indicator-Specific Harm Weights and Population-Specific Volume Weights**

| **Component** | **PSI 03** | **PSI 06** | **PSI 08** | **PSI 09** | **PSI 10** | **PSI 11** | **PSI 12** | **PSI 13** | **PSI 14** | **PSI 15** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Harm Weight | 0.3080 | 0.1381 | 0.1440 | 0.0570 | 0.3584 | 0.2219 | 0.1557 | 0.3102 | 0.1441 | 0.1474 |
| CMS Medicare FFS Volume Weight | 0.1039 | 0.0566 | 0.0212 | 0.1489 | 0.0451 | 0.1657 | 0.2403 | 0.1553 | 0.0128 | 0.0500 |
| Final CMS Medicare FFS Weight | 0.1608 | 0.0392 | 0.0154 | 0.0426 | 0.0812 | 0.1846 | 0.1879 | 0.2419 | 0.0093 | 0.0370 |
| AHRQ All-Payer Volume Weight | 0.0860 | 0.0538 | 0.0172 | 0.1598 | 0.0280 | 0.1821 | 0.2543 | 0.1550 | 0.0138 | 0.0500 |
| Final AHRQ All-Payer Weight | 0.1373 | 0.0385 | 0.0128 | 0.0472 | 0.0520 | 0.2094 | 0.2052 | 0.2491 | 0.0103 | 0.0382 |

**2d2.3. What is your interpretation of the results in terms of demonstrating the aggregation and weighting rules are consistent with the described quality construct?** (i*.e., what do the results mean in terms of supporting the selected rules for aggregation and weighting; if no empirical analysis, provide rationale for the selected rules for aggregation and weighting*)

In the first row, **Table 26** shows the harm weight (excess harm and disutility) for each PSI 90 component; these harm weights are updated every 3-5 years and are intended for use with any application of PSI 90. These harm weights demonstrated the expected patterns, with indicators such as postoperative sepsis, which are associated with higher mortality rates, having higher harm weights than less serious events.

The second row shows volume weights from the Medicare FFS population, while the fourth row shows volume weights from the AHRQ all-payer population. The final weight on each component measure is proportional to the relative incidence of that event in the appropriate reference population, reflecting the overall level of harm associated with each PSI in that reference population. For example, PSI 03 carries a higher weight in CMS Medicare PSI 90 than in AHRQ’s implementation simply because pressure injuries have higher incidence in the Medicare FFS population than in the all-payer population.

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8. <https://www.qualitynet.org/inpatient/measures/psi/resources>, accessed May 29, 2020. [↑](#footnote-ref-9)
9. <https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/MMS/MMS-Blueprint>, accessed 7/26/2020. [↑](#footnote-ref-10)
10. <https://www.hcup-us.ahrq.gov/toolssoftware/comorbidityicd10/comorbidity_icd10.jsp> [↑](#footnote-ref-11)
11. MDCs fully described in Table A.3 of the PSI Parameter Estimates: <https://www.qualityindicators.ahrq.gov/Downloads/Modules/PSI/V2019/Parameter_Estimates_PSI_v2019.pdf> [↑](#footnote-ref-12)
12. MDRGs fully described in Table A.2 of the PSI Parameter Estimates: <https://www.qualityindicators.ahrq.gov/Downloads/Modules/PSI/V2019/Parameter_Estimates_PSI_v2019.pdf> [↑](#footnote-ref-13)
13. <https://www.hcup-us.ahrq.gov/toolssoftware/comorbidityicd10/comorbidity_icd10.jsp> [↑](#footnote-ref-14)
14. MDCs fully described in Table A.3 of the PSI Parameter Estimates <https://www.qualityindicators.ahrq.gov/Downloads/Modules/PSI/V2019/Parameter_Estimates_PSI_v2019.pdf> [↑](#footnote-ref-15)
15. MDRGs fully described in Table A.2 of the PSI Parameter Estimates <https://www.qualityindicators.ahrq.gov/Downloads/Modules/PSI/V2019/Parameter_Estimates_PSI_v2019.pdf> [↑](#footnote-ref-16)