Hybrid Hospital-Wide Mortality (HWM) Measure Submission to PQM: Figures and Tables

Table of Figures

Table of Tables

Figure 1. HWM Flow Diagram of Inclusion and Exclusion Criteria and Specialty Cohort Assignment for the Index Admission

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                        ┌─────────────────────────────────┐
                        │  Short-term acute care admission │
                        └─────────────────────────────────┘
                                       │
                                       ▼
┌─────────────────────────────────────────────────────────────────────────────┐
│ Meets ALL of the following criteria:                                          │
│  • Enrolled in Medicare FFS/MA for one year prior to the index admission      │
│    and during the month of the start date of the admission                    │
│  • Aged between 65 and 94                                                      │            No
│  • Not transferred in from another acute care facility                        │
│  • Not primarily treated for non-acute care (psychiatric care or              │
│    rehabilitation)                                                            │
│  • Not enrolled in Medicare hospice 12 months prior to, on day of index       │
│    admission, or within first 2 days of admission                             │
│  • Not primarily treated for cancer and enrolled in hospice at any time       │
│    during admission stay                                                      │
│  • Not with metastatic cancer                                                 │
│  • Not with select diagnoses for which hospitals have limited ability to      │
│    influence survival                                                         │
└─────────────────────────────────────────────────────────────────────────────┘
                                       │ Yes
                                       ▼
┌─────────────────────────────────────────────────────────────────────────────┐
│ Meets ANY of the following criteria:                                          │
│  • Discharged against medical advice                                          │
│  • Inconsistent or unknown vital status                                       │            Yes
│  • Primarily treated for crush injury, burns, intracranial injury, spinal     │
│    cord injury, skull and face fracture, or open wounds of head, neck,        │
│    and trunk                                                                  │
│  • With a principal or secondary diagnosis of COVID-19                        │
│  • With a principal diagnosis not assigned to any of the 15 divisions         │
│  • Hospitalizations not randomly selected (one index admission/patient/year)  │
│  • With an admission in a low volume CCS, defined as less than 100 admissions │
│  • Admissions missing more than 5 of the 10 CCDE                              │
└─────────────────────────────────────────────────────────────────────────────┘
                                       │ No
                                       ▼
```

Excluded from the measure

```
┌───────────────────────────────────────────────────┐
│              Admission for major surgery           │
│  (one of the defined AHRQ CCS procedure categories │
│   or ICD-10-PCS codes in the Supplemental File)    │
└───────────────────────────────────────────────────┘
       │ Yes                              │ No
       ▼                                  ▼
┌─────────────────────┐        ┌─────────────────────────┐
│  Surgical Division  │        │  Non-surgical Division  │
│ (as defined by AHRQ │        │ (as defined by AHRQ CCS │
│  CCS in Supplemental│        │  in Supplemental File)  │
│  File)              │        │                         │
└─────────────────────┘        └─────────────────────────┘
       │                                  │
       ▼                                  ▼
```

Assigned to one of:
- Cardiothoracic
- Cancer
- General
- Mixed
- Neurosurgery
- Orthopedics

Assigned to one of:
- Cancer
- Cardiac
- Gastroenterology
- Infectious Disease
- Mixed
- Neurology
- Orthopedic
- Pulmonary
- Renal

Figure 2. Hybrid HWM Logic Model

Healthcare Process

- Delivery of timely, high-quality, guideline-driven care
  - Supplemental oxygen
  - Noninvasive ventilation
- Reducing the risk of infection and other complications
- Ensuring patient is ready for discharge
- Improving communication among providers involved at care transition
- Reconciling medications
- Providing adequate staffing to meet the needs of patients
- Educating patients about symptoms, whom to contact with questions, and where and when to seek follow-up care
- Encouraging strategies that promote disease management

→

Patient Health

Improved health status

→

Outcome

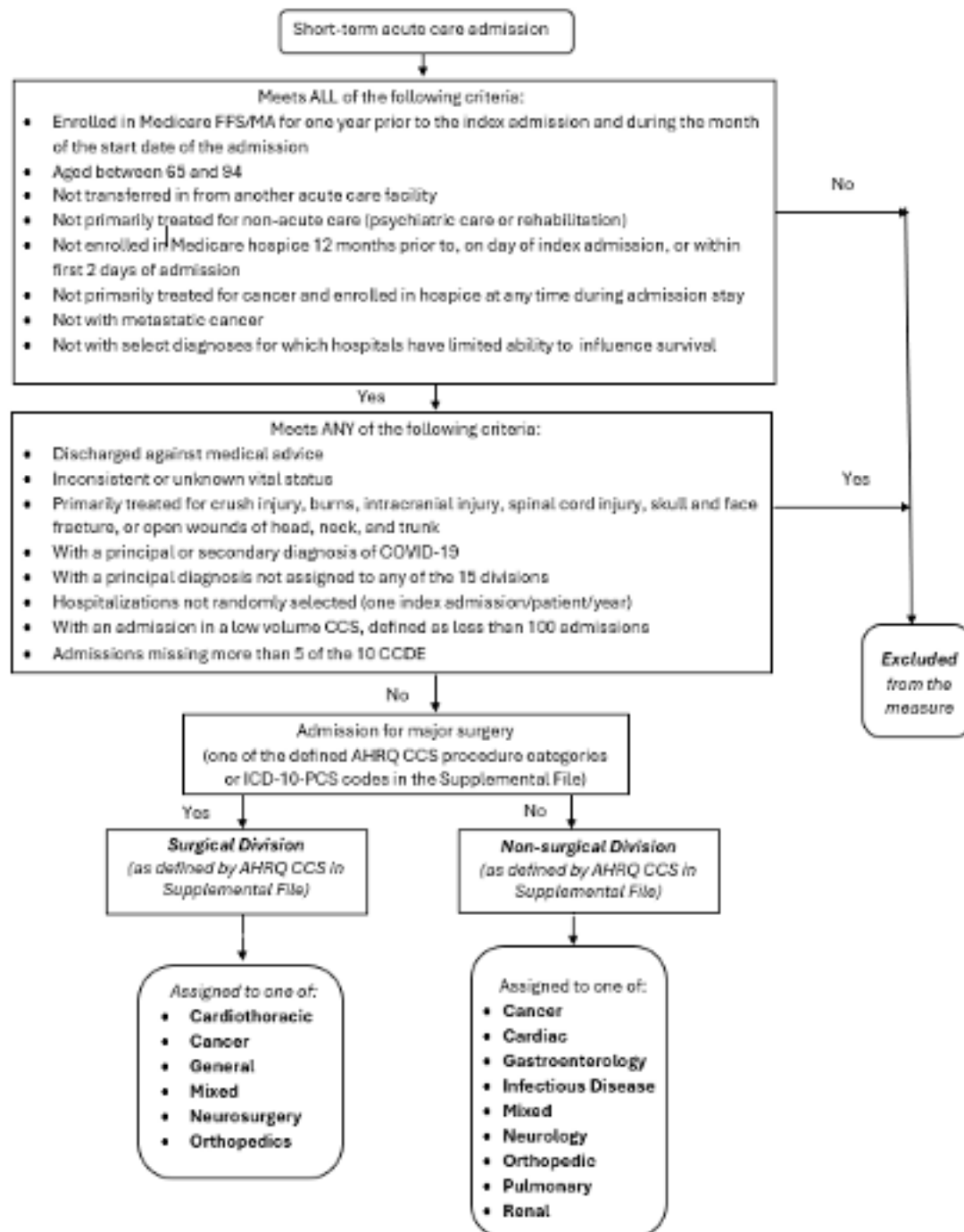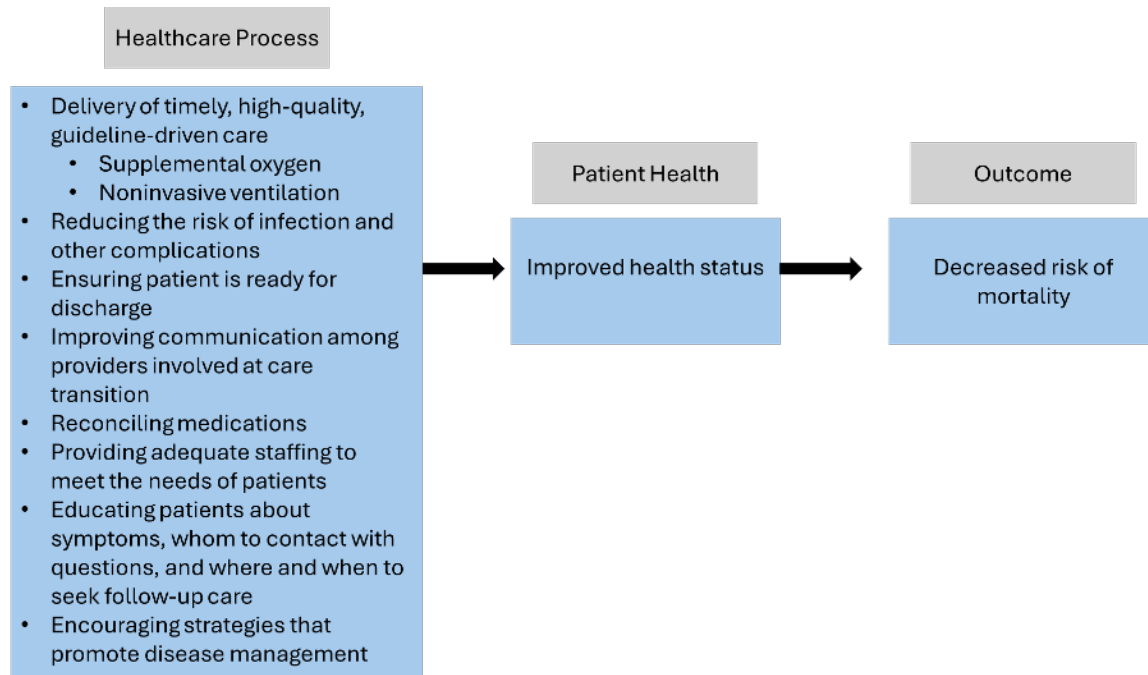Decreased risk of mortality

Table 1. RSMR by Decile—Claims-Only HWM (Medicare FFS + MA) dataset (Discharges July 1, 2018, through June 30, 2019)

	Overall	Min	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10	Max
Mean Score	6.34%	1.52%	5.26%	5.77%	6.00%	6.15%	6.27%	6.37%	6.52%	6.69%	6.90%	7.55%	11.60%
Entities	4,743	1	474	474	475	474	474	475	474	475	474	474	1
Total Persons	6,883,980	387	1,552,824	977,525	780,570	589,718	400,071	489,024	484,391	486,414	528,924	594,519	1,113

Table 2. Claims-Only HWM (Medicare FFS + MA) dataset Measure Score (Risk-Standardized Mortality Rate or RSMR) Distribution for Discharges July 1, 2018, through June 30, 2019

Description	Value
Number of Hospitals	4,743
Mean and Standard Deviation	6.12% (0.76%)
0% Min	1.52%
10%	5.22%
25% Q1	5.67%
50% Median	6.11%
75% Q3	6.56%
90%	6.97%
95%	7.28%
99%	8.05%
100% Max	11.60%

Table 3. Hybrid HWM 2024 Voluntary Reporting Dataset Measure Score (Risk-Standardized Readmission Rate or RSMR) Distribution for Discharges July 1, 2022 through June 30, 2023

Description	Value
Number of hospitals	1,136
Mean and Standard Deviation	3.95% (0.62%)
0% Min	2.16%
10%	3.22%
25% Q1	3.56%
50% Median	3.94%
75% Q3	4.33%
90%	4.71%
95%	4.97%
99%	5.42%
100% Max	6.17%

Figure 3. Distribution (Histogram) Of Hospital-Wide RSMRs (Claims-Only HWM [Medicare FFS + MA] dataset) for Discharges July 1, 2018, through June 30, 2019
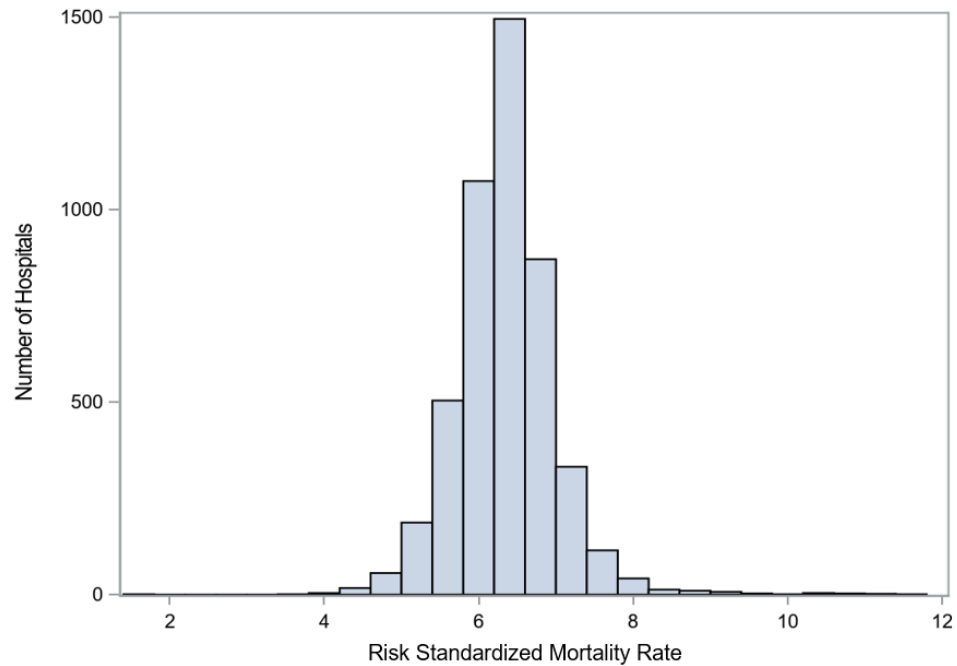

Figure 4. Distribution (Histogram) of Hospital-Wide RSMRs (Hybrid HWM 2024 Voluntary Reporting Dataset) for Discharges July 1, 2022-June 30, 2023
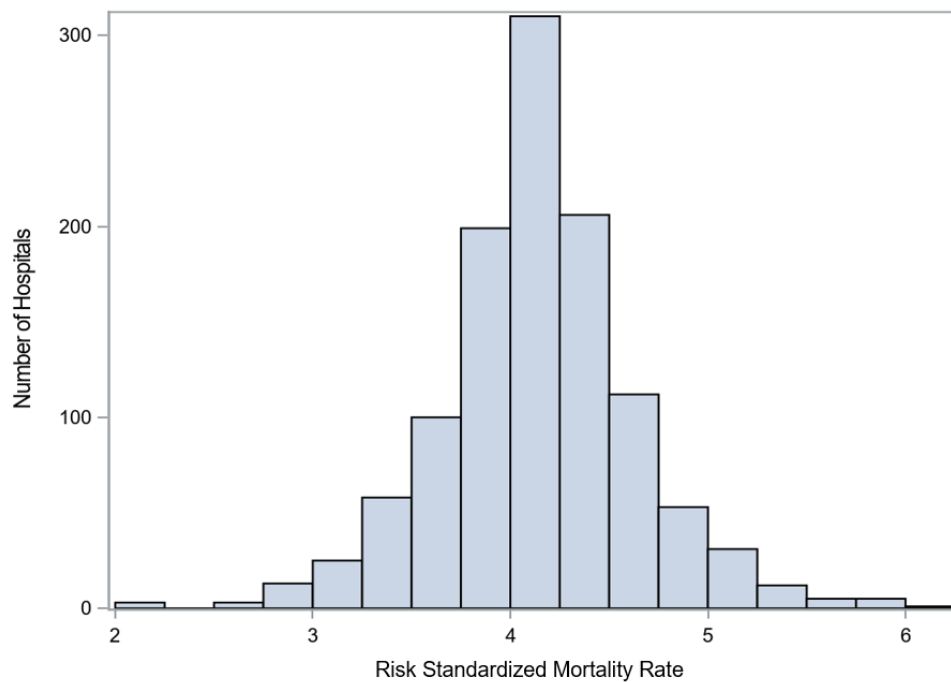
Table 4. Dataset Descriptions

Dataset	Applicable Section in the Testing Attachment	Description of Dataset
Claims-based All Cause Unplanned Hospital-Wide Mortality (HWM) Dataset (Medicare FFS and Medicare Advantage) **(Dataset 2, 2a – Development; 2b - Validation)** **For testing, we used a one-year dataset containing combined FFS + MA inpatient claims for patients discharged between July 1, 2018, through June 30, 2019, from acute care hospitals. This dataset does not include CCDE for case-mix risk adjustment, but it is utilized to represent the Medicare Advantage population, for which the measure cohort was recently expanded for 2026 Reporting through rulemaking.**	• Performance gap • Risk Adjustment/ Stratification • Statistical Risk Model Calibration Statistics • Reliability (Measure Score) • Validity (Empiric) • Equity	Dates of Data: July 1, 2018, through June 30, 2019 Number of admissions = 6,883,980 Number of hospitals = 4,743 Patient Descriptive Characteristics: mean age = 77 years; standard deviation = 8 years The number of index admissions is listed below by division. **Non-Surgical- Cancer** Overall: 57,183 Development: 28,536 Validation: 28,536 **Non-Surgical- Cardiac** Overall: 767,734 Development 383,855 Validation 383,854 **Non-Surgical- GI** Overall: 525,089 Development 262,544 Validation 262,545 **Non-Surgical- Infectious Disease** Overall: 890,338 Development 445,169 Validation 445,169 **Non-Surgical- Mixed** Overall: 679,324 Development 347,411 Validation 347,411 **Non-Surgical- Neurology** Overall: 358,029 Development 344,831 Validation 344,831 **Non-Surgical- Orthopedic** Overall: 215,431

Dataset	Applicable Section in the Testing Attachment	Description of Dataset
		Development 339,405 Validation 339,404 **Non-Surgical- Pulmonary** Overall: 694,879 Development 107,655 Validation 107,655 **Non-Surgical- Renal** Overall: 689,662 Development 179,014 Validation 179,015 **Surgical- Cardiothoracic** Overall: 205,058 Development 101,237 Validation 101,236 **Surgical- General** Overall: 314,630 Development 155,686 Validation 155,686 **Surgical- Neurosurgery** Overall: 53,139 Development 25,756 Validation 25,756 **Surgical- Orthopedics** Overall: 1,017,618 Development 50,7392 Validation 50,7392 **Surgical- Mixed** Overall: 297,679 Development 147,578 Validation 147,579 **Surgical- Cancer** Overall: 131,846 Development 65,921 Validation 65,921
Hybrid Hospital-Wide Mortality 2024 Voluntary Reporting Dataset **(Dataset 3, 3a – Development; 3b – Validation)**	• Performance gap • Risk Adjustment/ Stratification • Statistical Risk Model • Calibration Statistics • Reliability (Measure Score)	Dates of Data: July 1, 2022-June 30, 2023 Total number of hospitals for testing/ measure calculation: 1,136

Dataset	Applicable Section in the Testing Attachment	Description of Dataset
For testing, we used a one-year dataset containing combined FFS inpatient claims for patients discharged between July 1, 2022, through June 30, 2023, from acute care hospitals, matched with CCDE for claims-mix risk-adjustment. This dataset does not include Medicare Advantage patients but is used to represent a sample with CCDE reported by hospitals, for which the measure is specified.	• Missing Data	Total number of hospitals submitting CCDE (EHR dataset): 1,162 Total number of admissions: 1,538,437 Patient Descriptive Characteristics: Mean age= 78 Standard deviation= 8 **Non-Surgical- Cancer** Overall: 9,213 Development 4,607 Validation 4,606 **Non-Surgical- Cardiac** Overall: 119,157 Development 59,578 Validation 59,579 **Non-Surgical- Gastrointestinal** Overall: 84,627 Development 42,314 Validation 42,313 **Non-Surgical- Infectious Disease** Overall: 141,120 Development 70,560 Validation 70,560 **Non-Surgical- Pulmonary** Overall: 89,495 Development 44,747 Validation 44,748 **Non-Surgical- Renal** Overall: 112,898 Development 56,449 Validation 56,449 **Non-Surgical- Mixed** Overall: 115,714 Development 57,857 Validation 57,857 **Non-Surgical- Orthopedic**

Dataset	Applicable Section in the Testing Attachment	Description of Dataset
		Overall: 36,743 Development 18,372 Validation 18,371 **Non-Surgical- Neurology** Overall: 62,611 Development 31,305 Validation 31,306 **Surgical- Cardiothoracic** Overall: 47,654 Development 23,827 Validation 23,827 **Surgical- General** Overall: 50,250 Development 25,125 Validation 25,125 **Surgical- Neurosurgery** Overall: 12,809 Development 6,405 Validation 6,404 **Surgical- Orthopedics** Overall: 99,291 Development 49,645 Validation 49,646 **Surgical- Mixed** Overall: 49,324 Development 24,662 Validation 24,662 **Surgical- Cancer** Overall: 20,922 Development 10,461 Validation 10,461
Development and Validation Datasets (Kaiser Permanente merged clinical and EHR dataset) **(Dataset 1, 1a – Development; 1b - Validation)**	• Feasibility (Data Element)	Dates of Data: Development/Validation sample= January 1, 2010 – December 31, 2012 2012 sample= January 1, 2012—December 31, 2012 Number of admissions = 381,980 Number of hospitals = 21

Dataset	Applicable Section in the Testing Attachment	Description of Dataset
This data source includes all-payer inpatient claims for all adults merged with clinical data elements derived from patients' EHRs, using three years of data, in which the third year (2012 sample) was used to test stability.		Patient Descriptive Characteristics: mean age = 58 years; standard deviation = 21 years %female = 62.6
Electronically extracted clinical data from three hospitals that used Cerner as their clinical EHR (Dataset 4)	• Validity (Data Element)	Dates of Data: January 1, 2010 through December 31, 2012 3 hospitals with 25,829; 56,812; and 29,586 admissions, respectively. This was inclusive of both Medicare FFS and Medicare Advantage, as data was all-payer.
Data element validity testing dataset (Dataset 5)	• Validity (Data Element)	Dates of Data: January 1, 2010 through December 31, 2012 Data were electronically extracted from EHR for 391 admissions, from an individual hospital using GE Centricity as their EHR vendor. This was inclusive of both Medicare FFS and Medicare Advantage, as data was all-payer.
ADI index	• Social risk factor testing	Dates of Data: July 2023 We used ADI data to derive areas of socioeconomic disadvantage based on zip code, for use in studying the association between the HWM measure and social risk factors.

Table 6. Hypothesized Strength and Direction of Association of Measure Scores with the Hospital-Wide Mortality Measure Score

Candidate Measure for Validity testing	Hypothesized Strength of Association	Hypothesized Direction of Association
Nurse-to-bed Ratio	Weak/Moderate	Negative
Hospital Star Rating Mortality Group Score	Weak/Moderate	Negative
Overall Hospital Star Rating Summary Score	Weak/Moderate	Negative

Table 7. Percent Agreement and Confidence Internals for CCDE (Dataset 4-Cerner and 5-GE Centricity) for Discharges July 1, 2018, through June 30, 2019

Data Element/ CCDE	% Agreement Between Datasets (Number Matching/ Total Records With Abstracted and Electronic Data)	95% Confidence Internal for Agreement	% Present in Electronic Extraction, Missing in Manual Abstraction (N)	% Present in Manual Abstraction, Missing in Electronic Extraction (N)	% Missing in Both Electronic Extraction and Manual Abstraction (N)
Dataset 4 (n=368)					
Heart rate (BPM)	95.55 (322/337)	92.76 - 97.49	0 (0.00)	8.42 (31)	0 (0.00)
Systolic Blood Pressure (mmHG)	94.67 (320/338)	91.71 - 96.81	0 (0.00)	8.15 (30)	0 (0.00)
Respiratory Rate (BPM)	94.89 (316/333)	91.95 - 97.00	0 (0.00)	9.51 (35)	0 (0.00)
Temperature (C)	95.41 (312/327)	92.55 - 97.41	0 (0.00)	10.87 (40)	0.27 (1)
Oxygen Saturation (%)	94.68 (285/301)	91.51 - 96.93	0.27 (1)	14.40 (53)	3.53 (13)
Weight (Kg)*	14.66 (51/348)	11.11 - 18.81	1.09 (4)	3.53 (13)	0.82 (3)
Hematocrit (%)	96.19 (328/341)	93.57 - 97.95	0.82 (3)	3.80 (14)	2.72 (10)
Platelet (x10(9)/L)	96.88 (310/320)	94.33 - 98.49	0.82 (3)	4.62 (17)	7.61 (28)
WBC Count (x10(9)/L)	96.56 (309/320)	93.93 - 98.27	0.82 (3)	4.62 (17)	7.61 (28)
Potassium (meq/L)	97.22 (280/288)	94.60 - 98.79	0 (0.00)	5.16 (19)	16.58 (61)
Sodium (meq/L)	97.21 (279/287)	94.58 - 98.79	0 (0.00)	5.43 (20)	16.58 (61)

Data Element/ CCDE	% Agreement Between Datasets (Number Matching/ Total Records With Abstracted and Electronic Data)	95% Confidence Internal for Agreement	% Present in Electronic Extraction, Missing in Manual Abstraction (N)	% Present in Manual Abstraction, Missing in Electronic Extraction (N)	% Missing in Both Electronic Extraction and Manual Abstraction (N)
Bicarbonate (meq/L)	14.81 (8/54)	6.62 - 27.12	0.27 (1)	68.21 (251)	16.85 (62)
Glucose (mg/dL)	96.14 (274/285)	93.20 - 98.06	0 (0.00)	5.43 (20)	17.12 (63)
Dataset 5 (n=391)					
Heart rate (BPM)	57.45 (135/235)	50.85 - 63.85	0 (0.00)	39.39 (154)	0.51 (2)
Systolic Blood Pressure (mmHG)	60.26 (138/235)	53.61 - 66.65	0 (0.00)	40.92 (160)	0.51 (2)
Respiratory Rate (BPM)	70.14 (155/221)	63.63 - 76.09	0 (0.00)	42.71 (167)	0.77 (3)
Temperature (C)	79.09 (174/220)	73.11 - 84.27	0 (0.00)	42.46 (166)	1.28 (5)
Oxygen Saturation (%)	56.65 (115/203)	49.53 - 63.57	0.26 (1)	46.80 (183)	1.02 (4)
Weight (Kg)	84.41 (157/186)	78.38 - 89.30	0.26 (1)	48.34 (189)	3.84 (15)
Hematocrit (%)	91.67 (88/96)	84.24 - 96.33	0.26 (1)	58.31 (228)	16.88 (66)
Platelet (x10(9)/L)	94.68 (89/94)	88.02 - 98.25	0.26 (1)	59.08 (231)	16.62 (65)
WBC Count (x10(9)/L)	94.62 (88/93)	87.90 - 98.23	0.26 (1)	59.34 (232)	16.62 (65)
Potassium (meq/L)	86.75 (72/83)	77.52 - 93.19	0 (0.00)	62.66 (245)	16.11 (63)
Sodium (meq/L)	91.46 (75/82)	83.20 - 96.50	0 (0.00)	61.64 (241)	17.39 (68)
Bicarbonate (meq/L)	29.41 (5/17)	10.31 - 55.96	0.26 (1)	77.49 (303)	17.90 (70)
Glucose (mg/dL)	95.12 (78/82)	87.98 - 98.66	0 (0.00)	63.17 (247)	15.86 (62)

*Capture for weight is within the first 24 hours of admission because it is not likely to change substantially during that timeframe.

Table 8. CCDE Missingness among Divisions using Hybrid HWM 2024 Voluntary Reporting dataset for discharges July 1, 2022-June 30, 2023

Description	Non-Surgical: Cancer	Non-Surgical: Cardiac	Non-Surgical: GI	Non-Surgical: Infectious Disease	Non-Surgical: Pulmonary	Non-Surgical: Renal	Non-Surgical: Mixed	Non-Surgical: Orthopedic	Non-Surgical: Neurology	Surgical: CT	Surgical: General	Surgical: Neurosurgery	Surgical: Orthopedics	Surgical: Mixed	Surgical: Cancer
Bicarbonate # (%)	525 (5.70%)	8,730 (7.33%)	5,856 (6.92%)	8,913 (6.32%)	5,371 (6.00%)	6,904 (6.12%)	7,708 (6.66%)	2,881 (7.84%)	4,547 (7.26%)	2,863 (6.01%)	4,125 (8.21%)	1,677 (13.09%)	12,421 (12.51%)	3,962 (8.03%)	1,770 (8.46%)
Creatinine # (%)	129 (1.40%)	1,744 (1.46%)	1,251 (1.48%)	1,693 (1.20%)	1,188 (1.33%)	1,062 (0.94%)	1,908 (1.65%)	760 (2.07%)	769 (1.23%)	1,205 (2.53%)	1,447 (2.88%)	1,356 (10.59%)	7,100 (7.15%)	1,677 (3.40%)	1,093 (5.22%)
Heart Rate # (%)	274 (2.97%)	3,098 (2.60%)	1,853 (2.19%)	2,809 (1.99%)	1,683 (1.88%)	2,304 (2.04%)	2,766 (2.39%)	841 (2.29%)	1,256 (2.01%)	2,102 (4.41%)	1,492 (2.97%)	371 (2.90%)	2,662 (2.68%)	1,672 (3.39%)	764 (3.65%)
Hematocrit # (%)	159 (1.73%)	4,558 (3.83%)	1,319 (1.56%)	2,054 (1.46%)	1,569 (1.75%)	3,347 (2.96%)	3,041 (2.63%)	1,173 (3.19%)	1,695 (2.71%)	1,044 (2.19%)	1,024 (2.04%)	667 (5.21%)	3,134 (3.16%)	1,425 (2.89%)	763 (3.65%)
Oxygen Saturation # (%)	350 (3.80%)	5,077 (4.26%)	2,761 (3.26%)	4,882 (3.46%)	2,863 (3.20%)	3,472 (3.08%)	3,707 (3.20%)	1,145 (3.12%)	1,973 (3.15%)	2,965 (6.22%)	2,198 (4.37%)	543 (4.24%)	4,046 (4.07%)	2,161 (4.38%)	918 (4.39%)
Platelet # (%)	2,883 (31.29%)	39,841 (33.44%)	27,423 (32.40%)	45,439 (32.20%)	29,731 (33.22%)	37,668 (33.36%)	37,091 (32.05%)	11,544 (31.42%)	20,490 (32.73%)	14,217 (29.83%)	17,061 (33.95%)	4,626 (36.12%)	36,555 (36.82%)*	17,046 (34.56%)	7,595 (36.30%)
Sodium # (%)	178 (1.93%)	3,026 (2.54%)	19,83 (2.34%)	3,343 (2.37%)	2,045 (2.29%)	2,053 (1.82%)	2,871 (2.48%)	1,211 (3.30%)	1,457 (2.33%)	1,183 (2.48%)	1,892 (3.77%)	1,129 (8.81%)	7,921 (7.98%)	1,928 (3.91%)	965 (4.61%)
Systolic Blood Pressure # (%)	194 (2.11%)	2,081 (1.75%)	1,020 (1.21%)	1,597 (1.13%)	1,165 (1.30%)	1,374 (1.22%)	1,678 (1.45%)	373 (1.02%)	714 (1.14%)	1,730 (3.63%)	1,052 (2.09%)	287 (2.24%)	2,078 (2.09%)	1,151 (2.33%)	625 (2.99%)
Temperature # (%)	259 (2.81%)	4870 (4.09%)	1,765 (2.09%)	3112 (2.21%)	2,511 (2.81%)	3,055 (2.71%)	3,023 (2.61%)	921 (2.51%)	2,249 (3.59%)	2,846 (5.97%)	1,397 (2.78%)	389 (3.04%)	2,980 (3.00%)	1,741 (3.53%)	742 (3.55%)
White Blood Cell Count # (%)	1,381 (14.99%)	2,4544 (20.60%)	15,232 (18.00%)	25011 (17.72%)	16,695 (18.65%)	21,628 (19.16%)	21,306 (18.41%)	6,993 (19.03%)	12,099 (19.32%)	8,972 (18.83%)	9,495 (18.90%)	3,300 (25.76%)	24,444 (24.62%)	9,737 (19.74%)	4,094 (19.57%)

Table 9. Pearson Correlation of Related Measure Scores with the Hospital-Wide Mortality Measure Score using Claims-Based HWM (Medicare FFS and MA) dataset for Discharges July 1, 2018, through June 30, 2019

Candidate Measure for Validity testing	Number of Hospitals	Pearson Correlation Coefficient	p-value
Nurse-to-bed Ratio	4,544	-0.138	<.0001
Hospital Star Rating Mortality Group Score	3,995	-0.574	<.0001
Overall Hospital Star Rating Summary Score	3,354	-0.324	<.0001

Figure 5- Box-whisker plots of the HWM measure RSMRs within each quartile of Nurse-to-Bed Ratio for Discharges July 1, 2018, through June 30, 2019
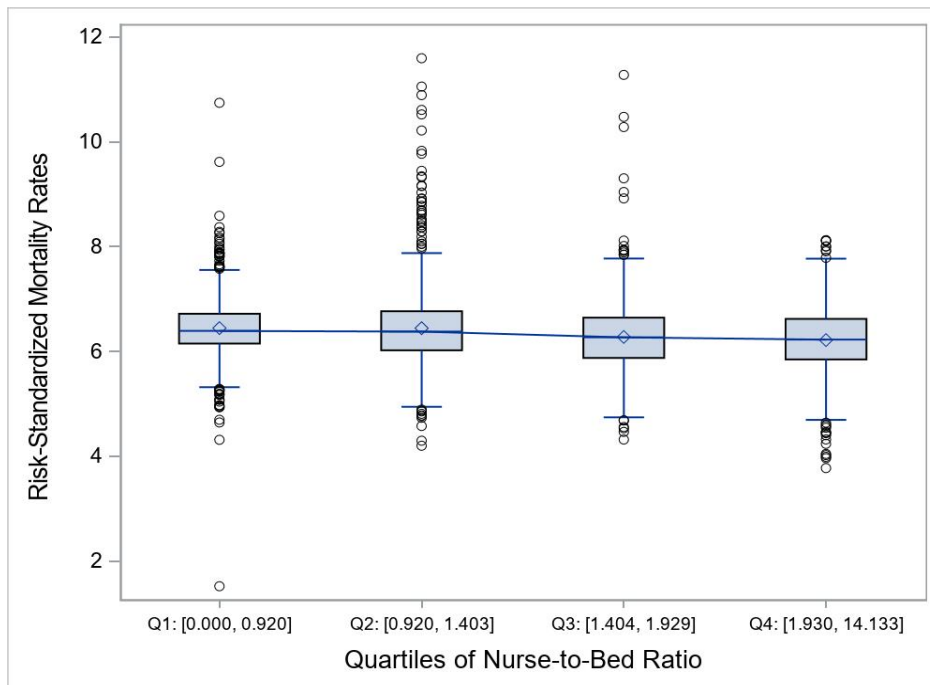
Figure 6- Box-whisker plots of the HWM measure RSMRs within each quartile of Star-Rating Mortality Group Scores for Discharges July 1, 2018, through June 30, 2019
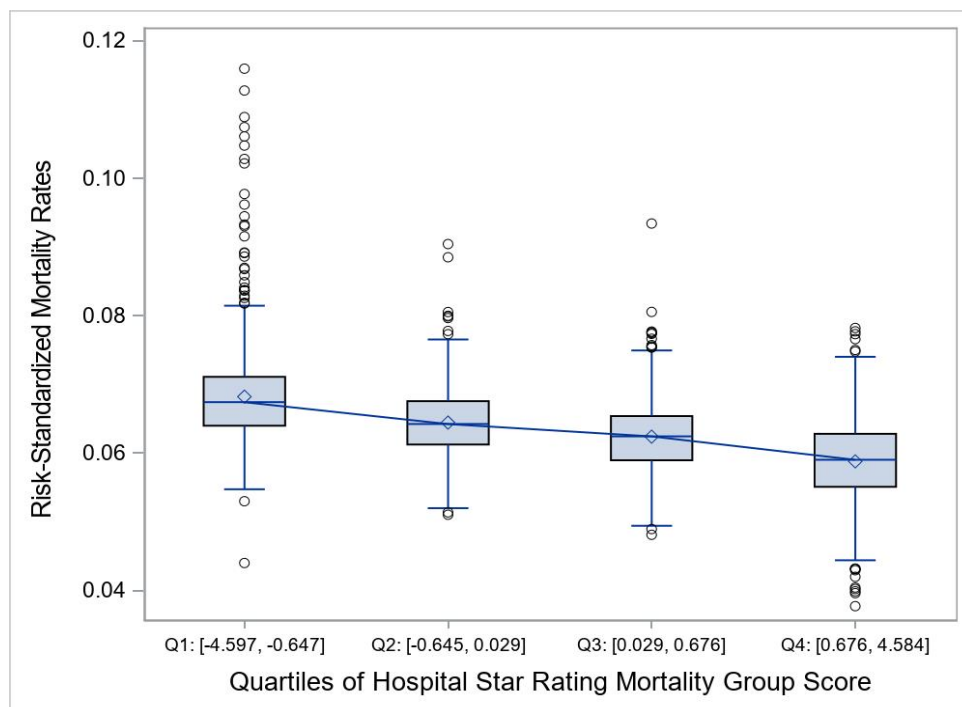

Figure 7 - Box-whisker plots of the HWM measure RSMRs within each quartile of the Overall Hospital Star Rating (removing mortality) for Discharges July 1, 2018, through June 30, 2019
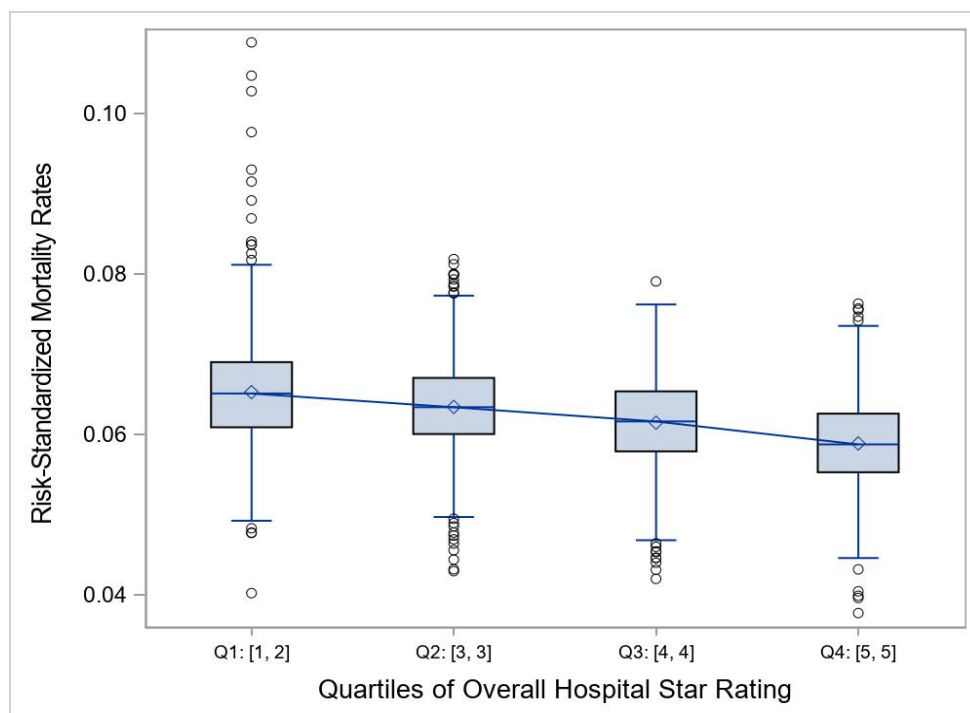
Table 10. Candidate Specified CCDE Variable

Clinical Data Elements	Units of Measurement	Window for First Captured Values
Patient Characteristics		
Age	Years	---
First-Captured Vital Signs		
Diastolic Blood Pressure	mmHg	0-2 hours
Heart Rate	Beats per minute	0-2 hours
Oxygen Saturation	Percent	0-2 hours
Respiratory Rate	Breath per minute	0-2 hours
Systolic Blood Pressure	mmHg	0-2 hours
Temperature	Degrees Fahrenheit	0-2 hours
Weight	Pounds	0-24 hours
First-Captured Laboratory Results		
Anion Gap	mEq/L	0-24 hours
Bicarbonate	mmol/L	0-24 hours
BUN	mg/dL	0-24 hours
Chloride	mEq/L	0-24 hours
Creatinine	mg/dL	0-24 hours
Glucose	mg/dL	0-24 hours
Hematocrit	% red blood cells	0-24 hours
Hemoglobin	g/dL	0-24 hours
Platelet	Count	0-24 hours
Potassium	mEq/L	0-24 hours
Sodium	mEq/L	0-24 hours
WBC Count	Cells/mL	0-24 hours

Table 11. Candidate Clinical EHR Risk Variable (CCDE) Mortality Association Modelling Approaches

Candidate EHR Risk Variables	Normal Range	Modeling Approach
Age	-	Linear
Diastolic Blood Pressure	-	Splined, knot at 80
Heart Rate	-	Linear
Oxygen Saturation	-	Linear
Respiratory Rate	-	Splined, knot at 16
Systolic Blood Pressure	-	Splined, knot at 140
Temperature	-	Linear
Weight	-	Splined, knot at 180
Anion Gap	7-17	Splined, knot at 10
Bicarbonate	22-30	Splined, knot at 26
BUN	8-18	Splined, knot at 14 and 40
Chloride	96-106	Linear
Creatinine	0.5-1.2	Linear, but Winsorized at 5
Glucose	70-100	Splined, knot at 180
Hematocrit	37-52	Linear
Hemoglobin	12-18	Linear
Platelets	140-144	Splined, knot at 200
Potassium	3.3-5.0	Splined, knot at 4.0
Sodium	135-145	Splined, knot at 140
White Blood Count	4.0-10.0	Splined, knot at 7.0

Table 12: C-statistic and Predictive Ability (Claims-Only HWM [Medicare FFS and MA] Dataset) for Discharges July 1, 2018, through June 30, 2019

Division	Predictive Ability		C-statistic
	Lowest Decile	Highest Decile	
Non-Surgical: Cancer	1.51%	35.04%	0.7452
Cardiac	0.26%	24.16%	0.8397
Gastrointestinal	0.28%	20.90%	0.8192
Infectious Disease	0.55%	45.19%	0.8205
Mixed	0.70%	32.00%	0.7896
Neurology	0.97%	27.03%	0.7578
Orthopedic	0.34%	22.17%	0.8045
Pulmonary	0.31%	18.28%	0.8018
Renal	0.39%	29.86%	0.8124
Surgical: Cardiothoracic	0.64%	30.34%	0.8296
General	0.28%	24.30%	0.8517
Neurosurgery	0.33%	16.70%	0.8857
Orthopedics	0.11%	09.60%	0.8925
Mixed	0.27%	21.93%	0.8631
Cancer	0.24%	10.51%	0.8057

Table 13. C-statistic and Predictive Ability (2024 Hybrid HWM Voluntary Reporting Testing Dataset) for Discharges July 1, 2022, through June 30, 2023

Division	Predictive Ability		C-statistic
	Lowest Decile	Highest Decile	
Non-Surgical: Cancer	0.76%	31.60%	0.7862
Cardiac	0.17%	13.81%	0.8267
Gastrointestinal	0.21%	14.46%	0.8146
Infectious Disease	0.40%	28.77%	0.8115
Mixed	0.25%	14.90%	0.7863
Neurology	0.26%	14.58%	0.7857
Orthopedic	0.19%	12.14%	0.7792
Pulmonary	0.53%	19.62%	0.7719
Renal	0.72%	18.42%	0.7519
Surgical: Cardiothoracic	0.64%	30.34%	0.8296
General	0.59%	12.82%	0.7947
Neurosurgery	0.24%	14.67%	0.8335
Orthopedics	0.08%	6.87%	0.8744
Mixed	0.12%	9.38%	0.8456
Cancer	0.28%	12.29%	0.8202

Table 14. Overfitting Statistics in the Development and Validation Sample—Claims-Only HWM (Medicare FFS and MA (dataset for Discharges July 1, 2018, through June 30, 2019)

Specialty Cohort	Development Sample Dataset 2a	Validation Sample Dataset 2b
Non-Surgical: Cancer	(0.000, 1.000)	(-0.041, 0.958)
Cardiac	(0.000, 1.000)	(0.030, 1.013)
Gastrointestinal	(0.000, 1.000)	(0.027, 1.010)
Infectious Disease	(0.000, 1.000)	(0.007, 1.003)
Mixed	(0.000, 1.000)	(0.005, 1.001)
Neurology	(0.000, 1.000)	(-0.002, 1.000)
Orthopedic	(0.000, 1.000)	(-0.013, 0.995)
Pulmonary	(0.000, 1.000)	(-0.011, 1.000)
Renal	(0.000, 1.000)	(-0.008, 0.997)
Surgical: Cardiothoracic	(0.000, 1.000)	(0.041, 1.012)
General	(0.000, 1.000)	(-0.066, 0.971)
Neurosurgery	(0.000, 1.000)	(-0.005, 1.004)
Orthopedics	(0.000, 1.000)	(-0.038, 0.986)
Mixed	(0.000, 1.000)	(-0.086, 0.965)
Cancer	(0.000, 1.000)	(0.044, 1.004)

Table 15. Overfitting in the Development and Validation Sample—Hybrid HWM 2024 Voluntary Reporting Dataset (discharges July 1, 2022-June 30, 2023)

Specialty Cohort	Development Sample Dataset 2a	Validation Sample Dataset 2b
Non-Surgical: Cancer	(0.000, 1.000)	(-0.197, 0.837)
Cardiac	(-0.001, 0.999)	(-0.086, 0.967)
Gastrointestinal	(-0.001, 0.999)	(-0.334, 0.876)
Infectious Disease	(0.000, 1.000)	(-0.060, 0.975)
Mixed	(0.000, 1.000)	(-0.114, 0.961)
Neurology	(0.000, 1.000)	(-0.014, 1.002)
Orthopedic	(0.000, 1.000)	(-0.220, 0.946)
Pulmonary	(0.001, 1.000)	(0.091, 1.034)
Renal	(0.000, 1.000)	(-0.155, 0.939)
Surgical: Cardiothoracic	(0.000, 1.000)	(-0.099, 0.975)
General	(0.000, 1.000)	(-0.203, 0.935)
Neurosurgery	(0.000, 1.000)	(-0.825, 0.737)
Orthopedics	(0.000, 1.000)	(0.073, 0.980)
Mixed	(0.000, 1.000)	(-0.230, 0.927)
Cancer	(0.000, 1.000)	(-0.288, 0.923)

Figure 8. Risk Decile Plot for all 15 HWM Divisions (Claims-Only HWM [Medicare FFS and MA] Dataset [for Discharges July 1, 2018, through June 30, 2019])
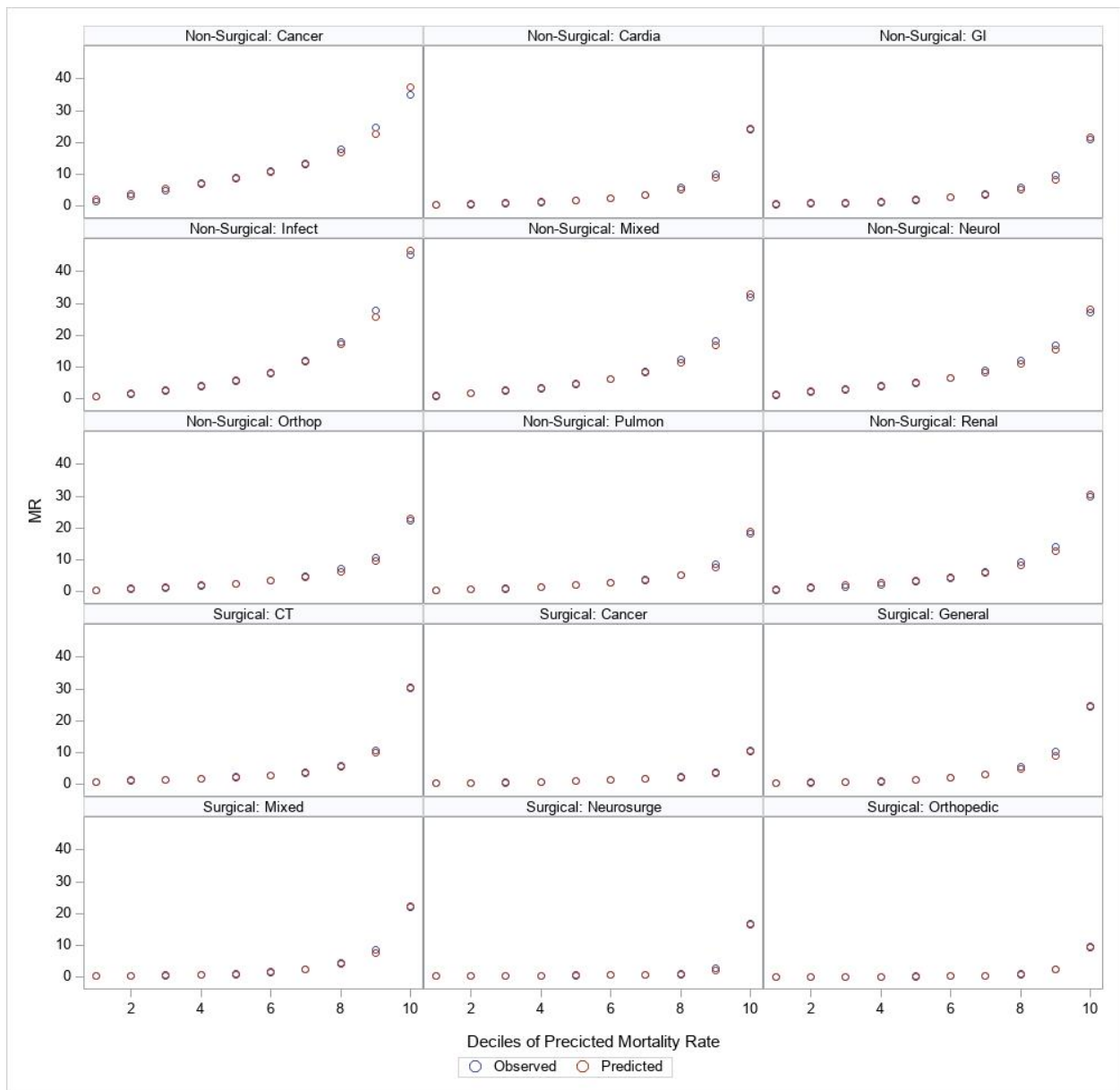
Figure 9. Risk Decile Plot for all 15 Hybrid HWM Divisions (Hybrid HWM 2024 Voluntary Reporting Dataset [discharges July 1, 2022-June 30, 2023])
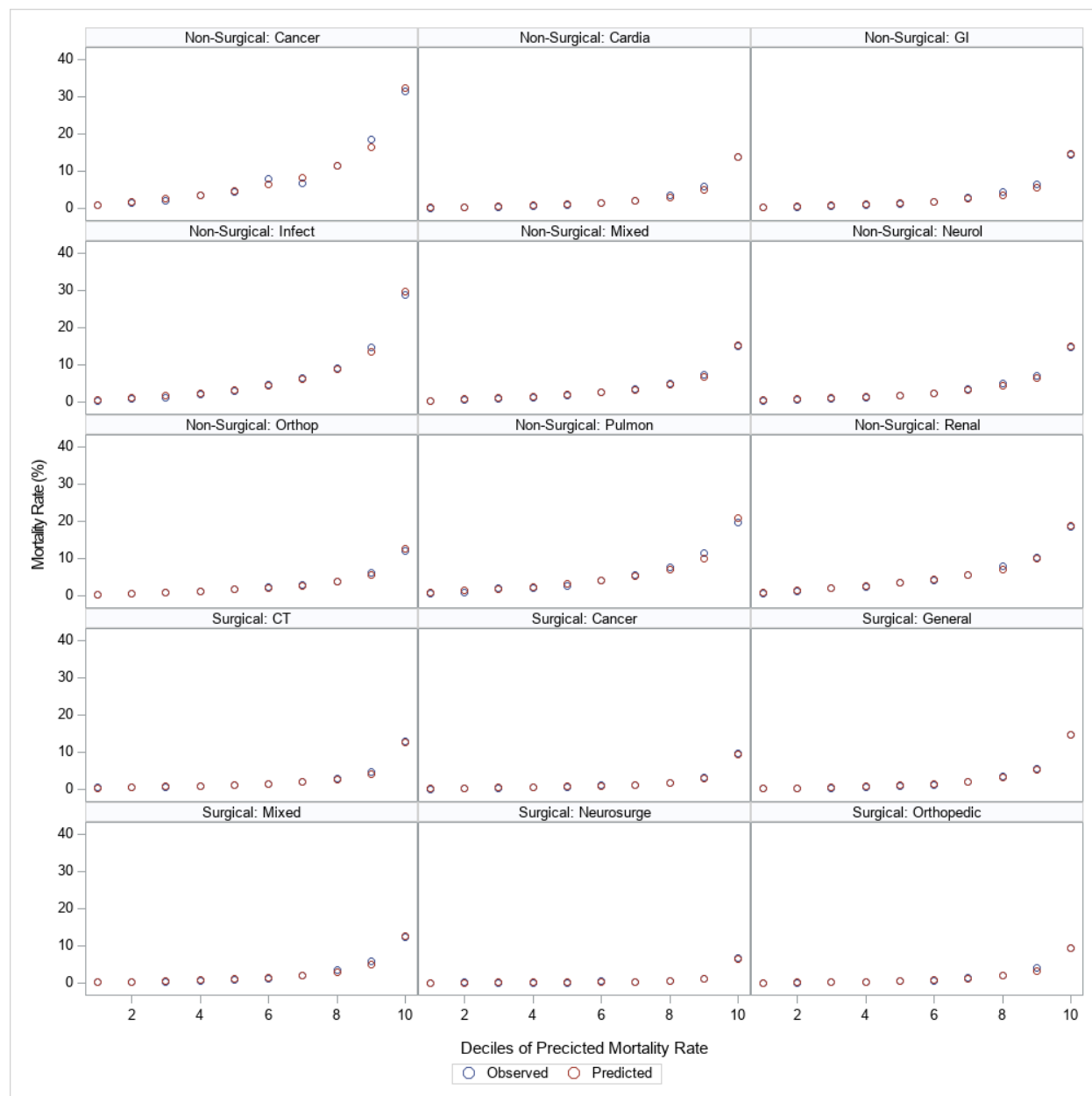
Table 16. Prevalence of social risk factors in the HWM cohort; Claims Only HWM (Medicare FFS and MA) dataset

Social Risk Factors	Hospital-Level Claims Only HWM (Medicare FFS and MA) Prevalence [Median % (IQR)] (N=4,737)
Dual-eligible (DE)	14.2% (9.4%-21.4%)
High Area Deprivation Index (ADI) (>=85)	10.5% (2.0%-26.8%)

Table 17. Observed mortality rates in patients with and without social risk factors (Claims Only HWM (Medicare FFS and MA) dataset

Social Risk Factors	Claims Only HWM (Medicare FFS and MA) [Observed Rate]
Dual-eligible (DE)	8.5%
Non-DE	5.9%
High Area Deprivation Index (ADI) (>=85)	7.2%
Low ADI (<85)	6.2%

Table 18. Differences in measure scores calculated with and without social risk factors (Claims-Only HWM [Medicare FFS and MA])

Metric	Difference in measure score (RSMR)		Measure Score Correlation
Social Risk Factor added	**Median**	**IQR**	**--**
High ADI	-0.0015	(-0.0198, 0.0144)	0.999
Dual-Eligibility	-0.0023	(-0.0106, 0.0032)	0.999

Figure 10. Measure Score Correlation with and without High ADI (Claims-Only HWM [Medicare FFS and MA])
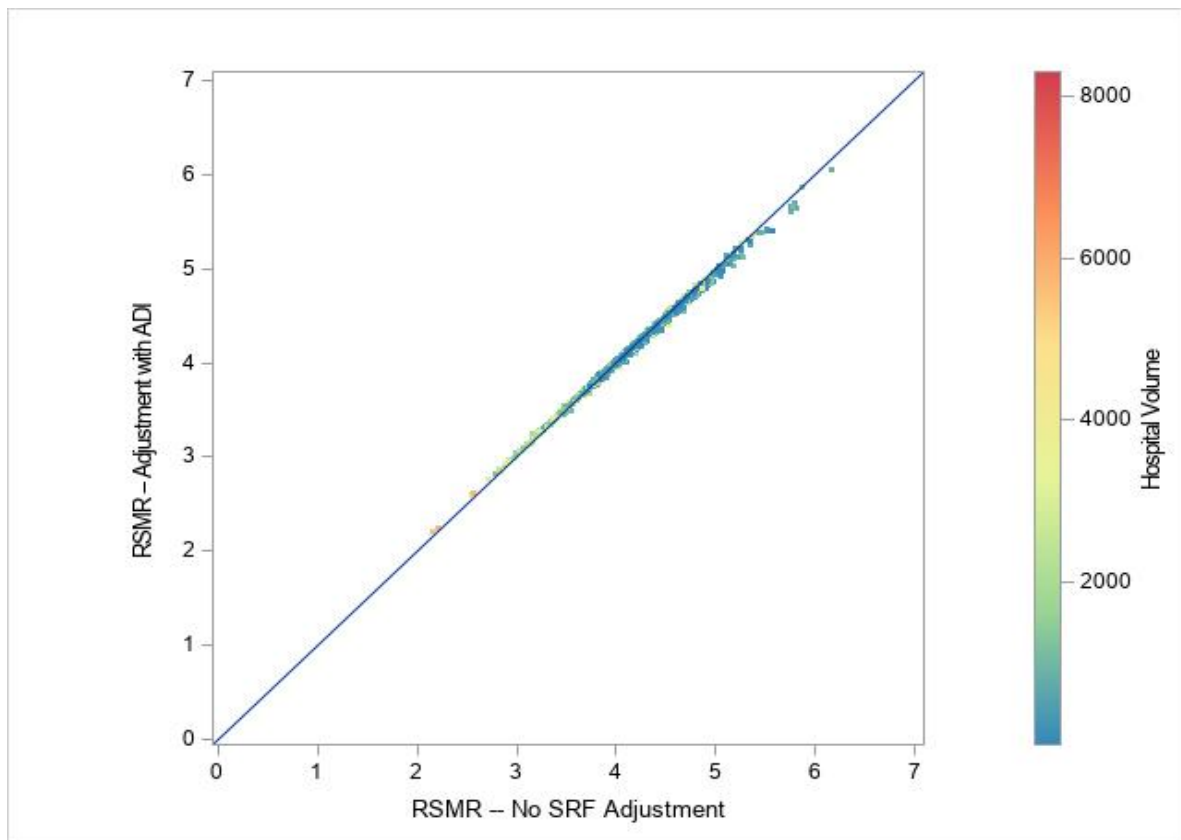
Figure 11. Measure Score Correlation with and without Dual-Eligibility (Claims-Only HWM [Medicare FFS and MA])