

Measure #2459 PCI in-hospital Risk Standardized rate of Bleeding events (No shock/no arrest)

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2.4 Performance Gap

Table 1. Performance Scores by Decile

The table below illustrates the distribution of the risk-standardized bleeding rates during the one-year observation period between 2021 and 2022. Included is the mean score, entities (or hospitals), and total encounters (or admissions), all evaluated by decile of performance from data collected from abstractors and reported to the CathPCI Registry. As illustrated in Table 1, the minimum RSBR was 0.55% whereas the maximum score was 26.7%, suggesting a wide gap in performance. Further, comparing those sites with the lowest and highest deciles of performance, 0.10% vs. 3.34%, respectively, demonstrates over a 3% difference in bleeding rates. While 3% may not appear to be a considerable gap, it translates to an additional 39,380 bleeds per year, justifying the importance of capturing and reporting these data.

Table 1. Mean Risk Standardized Bleeding Rates Stratified by Decile, % (1/1/2021-12/31/2022)

	Overall	Min	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10	Max
Mean Performance Score	0.0186	0.0055	0.0104	0.0128	0.0142	0.0156	0.0169	0.0181	0.0195	0.0215	0.0241	0.0334	0.2668
N of Entities	1704	1	170	170	171	170	171	170	171	170	171	170	1
N of Persons / Encounters / Episodes	1312961	1483	164404	132126	127997	110913	114943	115963	130561	121578	144116	150360	475

3.1 Contributions Towards Closing Care Gaps

We attributed social risk factors at the hospital-level for the purpose of this analysis. We used Medicaid insurance status as the economic indicator of social risk. We also examined age, sex, and race/ethnicity to determine if there were differences in these demographic indicators of social risk. Analyses of differences by subgroup were based on registry data procured from years 2021-22.

In terms of the overall distribution, the median risk standardized rate of bleeding was 1.74%, with an interquartile range of 1.43% to 2.16%. There is a right skew to the bleeding rates (Figure 1).

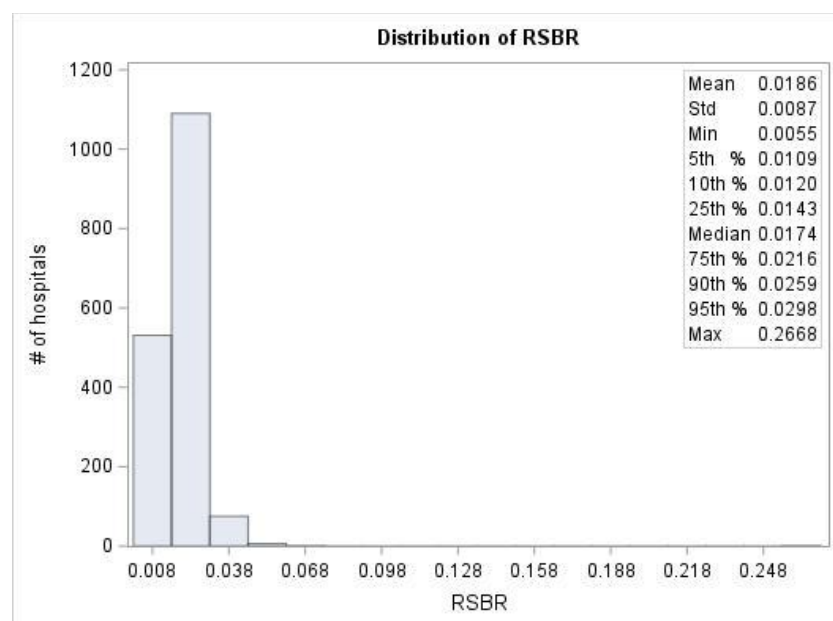
Overall

Table 2. Distribution of Risk Standardized Bleeding Rates Stratified by Hospital Volume

Description	Hospital Volume	Risk Standardized Bleeding Rates
N	1704	1704
Mean	770.52	0.0186
Std Deviation	678.61	0.0087
100% Max	7054	0.2668
99%	3126	0.0404
95%	2010	0.0298
90%	1623	0.0259
75% Q3	1059	0.0216

Description	Hospital Volume	Risk Standardized Bleeding Rates
50% Median	595	0.0174
25% Q1	296.5	0.0143
10%	136	0.0120
5%	78	0.0109
1%	20	0.0086
0% Min	1	0.0055
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Figure 1. Distribution of Risk Standardized Bleeding Rates



Subgroups

Across stratified analysis based on age, sex, patients insured through Medicaid, and proportion of non-white patients, we found significant overlap in the distribution of hospital performance, as detailed below.

Age

Hospitals (n=1,704) were stratified into quartiles by their proportion of patients over the age of 65 (median: 58.3%, IQR: 52.97% to 63.45%). Hospital performance was similar across hospitals stratified by quartile based on age (Table 3, Figure 2).

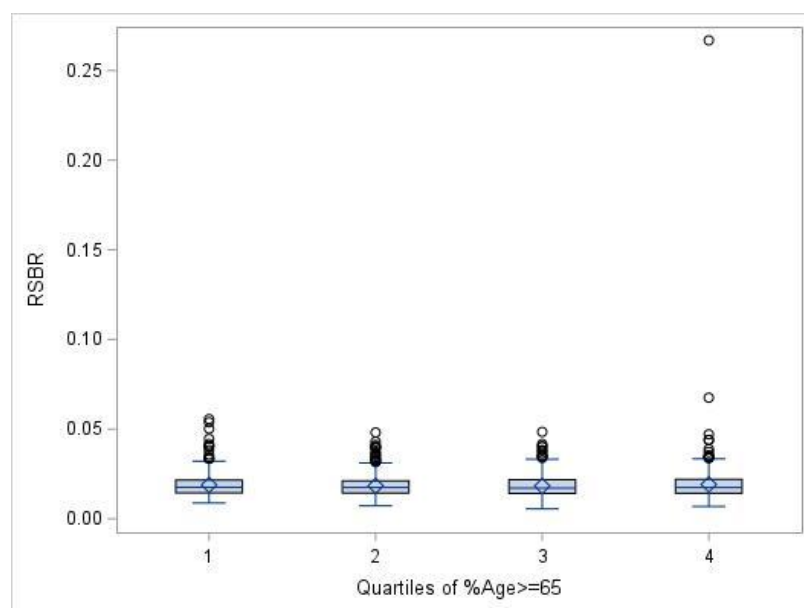
Table 3 Distribution of RSBR Stratified by Quartile of Hospital Percent Age ≥ 65

Description	%, Age ≥ 65			
	Q1	Q2	Q3	Q4
N	426	426	426	426
Mean	0.0189	0.0183	0.0183	0.0191
Std Deviation	0.0065	0.0061	0.0061	0.0137
100% Max	0.0556	0.0481	0.0484	0.2668

Description	%, Age \geq 65			
	Q1	Q2	Q3	Q4
99%	0.0417	0.0400	0.0382	0.0439
95%	0.0303	0.0290	0.0295	0.0297
90%	0.0261	0.0256	0.0259	0.0262
75% Q3	0.0216	0.0211	0.0218	0.0220
50% Median	0.0176	0.0175	0.0171	0.0174
25% Q1	0.0145	0.0143	0.0141	0.0142
10%	0.0126	0.0116	0.0116	0.0119
5%	0.0118	0.0109	0.0104	0.0103
1%	0.0094	0.0087	0.0082	0.0082
0% Min	0.0088	0.0072	0.0055	0.0069

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Figure 2. Distribution of RSBR Stratified by Quartile of Hospital Percent Age \geq 65



Sex

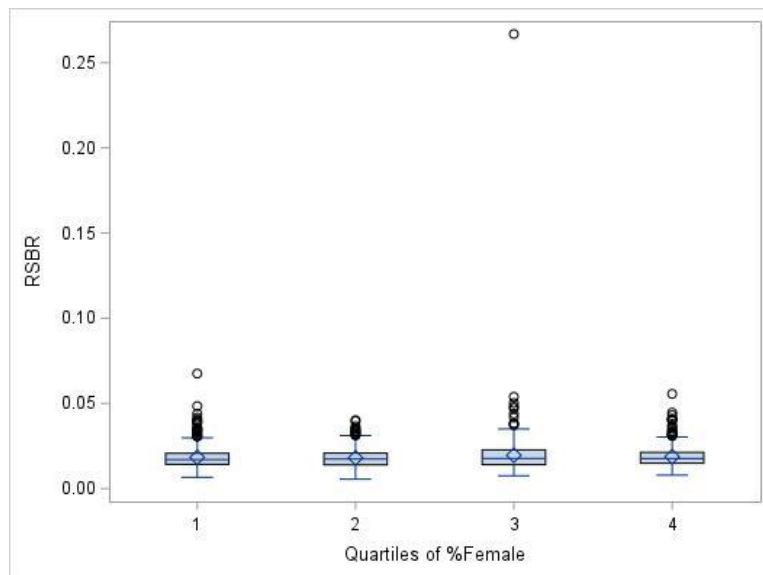
The median percent of female patients across sites was 30.95% (IQR: 28.04% to 33.95%), and hospitals performed similarly in RSBR across quartiles of proportion female.

Table 4. Distribution of RSBR Stratified by Quartile of Hospital Percent Female

Description	Female, %			
	Q1	Q2	Q3	Q4
N	425	426	427	426
Mean	0.0183	0.0180	0.0195	0.0187
Std Deviation	0.0066	0.0055	0.0138	0.0060
100% Max	0.0675	0.0402	0.2668	0.0556
99%	0.0404	0.0349	0.0471	0.0405
95%	0.0306	0.0285	0.0311	0.0297
90%	0.0259	0.0253	0.0275	0.0254
75% Q3	0.0207	0.0209	0.0227	0.0213
50% Median	0.0170	0.0173	0.0177	0.0176
25% Q1	0.0143	0.0140	0.0140	0.0149
10%	0.0120	0.0117	0.0117	0.0125
5%	0.0100	0.0107	0.0104	0.0115
1%	0.0074	0.0087	0.0085	0.0094
0% Min	0.0066	0.0055	0.0075	0.0079

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Figure 3. Distribution of RSBR Stratified by Quartile of Hospital Percent Female



Proportion on Non-White

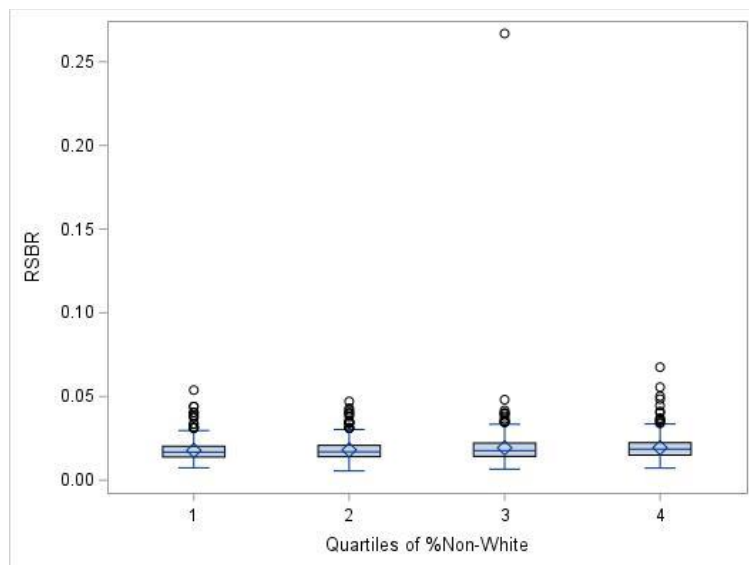
The median proportion of non-white patients was 12.12% (IQR: 5.43% to 23.23%). Hospitals that had a high proportion of non-white patients had slightly higher bleeding rates (1.86%) versus those hospitals with the lowest proportion of non-white patients (1.68%). (Table 5, Figure 4).

Table 5. Distribution of RSBP Stratified by Quartile of Hospital Percent Non-White

Description	Non-White, %			
	Q1	Q2	Q3	Q4
N	426	426	426	426
Mean	0.0178	0.0181	0.0193	0.0194
Std Deviation	0.0059	0.0061	0.0136	0.0067
100% Max	0.0538	0.0471	0.2668	0.0675
99%	0.0404	0.0402	0.0400	0.0446
95%	0.0277	0.0296	0.0306	0.0316
90%	0.0250	0.0259	0.0269	0.0263
75% Q3	0.0203	0.0208	0.0223	0.0224
50% Median	0.0168	0.0170	0.0177	0.0186
25% Q1	0.0138	0.0141	0.0142	0.0150
10%	0.0118	0.0118	0.0120	0.0126
5%	0.0105	0.0104	0.0109	0.0112
1%	0.0082	0.0082	0.0092	0.0093
0% Min	0.0074	0.0055	0.0066	0.0072

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Figure 4. Distribution of RSBP Stratified by Quartile of Hospital Percent Non-White



Insurance

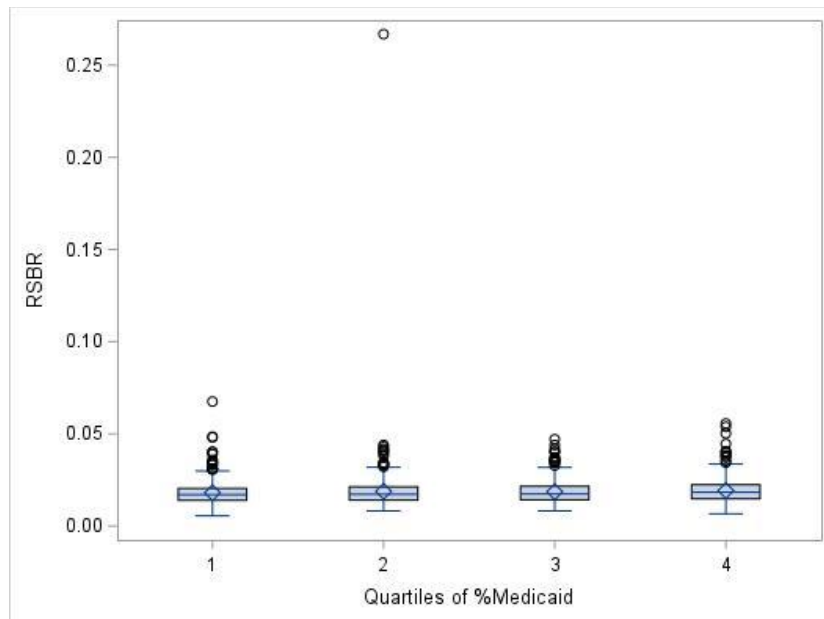
Hospitals (n=1,704) were stratified into quartiles by their proportion of patients with Medicaid as the primary insurance (median: 11.33%, IQR: 6.89% to 17.07%). Hospitals with the highest proportion of Medicaid recipients had higher bleeding rates (1.83%) compared to hospitals with the lowest rate of Medicaid recipients (1.70%).

Table 6. Distribution of RSBR Stratified by Quartile of Hospital Percent Medicaid

Description	Medicaid, %			
	Q1	Q2	Q3	Q4
N	426	425	427	426
Mean	0.0180	0.0188	0.0186	0.0192
Std Deviation	0.0064	0.0135	0.0062	0.0065
100% Max	0.0675	0.2668	0.0471	0.0556
99%	0.0402	0.0411	0.0400	0.0405
95%	0.0289	0.0299	0.0309	0.0297
90%	0.0254	0.0259	0.0259	0.0263
75% Q3	0.0204	0.0212	0.0216	0.0224
50% Median	0.0170	0.0172	0.0174	0.0183
25% Q1	0.0139	0.0141	0.0143	0.0148
10%	0.0118	0.0119	0.0118	0.0124
5%	0.0106	0.0105	0.0107	0.0111
1%	0.0074	0.0087	0.0093	0.0091
0% Min	0.0055	0.0082	0.0082	0.0066

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Figure 5: Distribution of RSBR Stratified by Quartile of Hospital Percent Medicaid



5.1.3 Characteristics of measured Entities

We did not use a sample of data for this measure; rather, we included all available data meeting inclusion criteria for the 2021-2022 observation period (n=1704 hospitals). Please refer to Table 7 for a description of hospital characteristics.

Table 7. Hospital Characteristics (n=1704)

Characteristic	#	%
All	1704	100.00
Participant Classification		
Hospital	1653	97.01
Outpatient Facility – Exclusive	1	0.06
Outpatient Facility – Supports	1	0.06
Hospital location		
Rural	363	21.30
Suburban	606	35.56
Urban	732	42.96
Participant type		
Government	34	2.00
Private/Community	1539	90.32
University	127	7.45
Teaching Hospital		
No	1028	60.33
Yes	676	39.67
Public Hospital		
No	1066	62.56
Yes	635	37.27
PCI Volume (Med [IQR])	375	505.50
Census Region		
Midwest Region	429	25.18
Northeast Region	250	14.67
South Region	710	41.67
West Region	315	18.49

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The table below (8) illustrates the development of the study sample (denominator) as exclusions were applied by number of patients and facilities.

Table 8. Development of the Study Cohort

Exclusions	Number of Patients		Number of Facilities	
	#	%	#	%
Initial Sample	1970524		1718	
Without PCI	690612	35.05	14	0.81
Remaining	1279912		1704	
Not first PCI during hospitalization	0	0.00	0	0.00
Remaining	1279912		1704	
In-hospital death within 24 hours of the procedure	9849	0.77	0	0.00
Remaining	1270063		1704	
Missing prior and post HGB	7839	0.62	0	0.00
Remaining	1262224		1704	
With CABG during hospitalization	9474	0.75	0	0.00
Remaining	1252750		1704	
With CA or shock on the admission	55761	4.45	0	0.00
Remaining	1196989		1704	
Salvage PCI	533	0.04	0	0.00
Final Study Sample	1196456		1704	

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5.1.4 Characteristics of Units of the Eligible Population

For the initial derivation and validation of the bleeding risk model, 1,312,961 patients undergoing PCI between 1/01/2021-12/31/2022 at 1,704 hospitals were included; 80% were randomly assigned to the derivation cohort with the remaining 20% serving as the validation cohort. Of these, 23,169 PCI procedures had post-procedure bleeding, yielding a post-PCI bleeding event rate of 1.76%. A summary of these patients' clinical characteristics and the hospital characteristics are provided under Table 9:

Table 9. Derivation and Validation Characteristics in the All-Patients Cohort Excluding Cardiac Arrest/Shock

Description	Total		Validation		Derivation	
	#	%	#	%	#	%
ALL	1312961	100.00	657252	100.00	655709	100.00
Demographics						

Description	Total		Validation		Derivation	
	#	%	#	%	#	%
Age: Mean (SD)	67.07	11.67	67.06	11.67	67.08	11.68
Female	402996	30.69	202110	30.75	200886	30.64
History and Risk Factors						
BMI						
Unknown	4982	0.38	2492	0.38	2490	0.38
Mean (SD)	30.17	6.54	30.17	6.55	30.16	6.53
Cerebrovascular disease	198470	15.12	99305	15.11	99165	15.12
Peripheral artery disease	152004	11.58	75919	11.55	76085	11.60
Chronic Lung disease	205007	15.61	102762	15.64	102245	15.59
Previous PCI	529574	40.33	264779	40.29	264795	40.38
GFR						
Unknown or not applicable	19875	1.51	9897	1.51	9978	1.52
Mean (SD)	70.67	24.08	70.71	24.10	70.64	24.07
Severe Frailty	36925	2.81	18558	2.82	18367	2.80
Clinical Instability (CI)						
Elective PCI and No CI	553310	42.14	277076	42.16	276234	42.13
Urgent PCI and No CI	509393	38.80	254977	38.79	254416	38.80
Emergency PCI and No CI	189448	14.43	94695	14.41	94753	14.45
CI	60428	4.60	30325	4.61	30103	4.59
Other	382	0.03	179	0.03	203	0.03
NYHA class within 2 weeks						
Missing or not applicable	1026	0.08	517	0.08	509	0.08
No CHF	962875	73.34	482033	73.34	480842	73.33
Class I/II/III	111478	8.49	55855	8.50	55623	8.48
Class IV	110793	8.44	55349	8.42	55444	8.46
Class I/II/III	98281	7.49	49160	7.48	49121	7.49
Class IV	28508	2.17	14338	2.18	14170	2.16
Heart Failure Type						
Missing or not applicable	998893	76.08	500124	76.09	498769	76.07
Diastolic heart failure	133255	10.15	66776	10.16	66479	10.14
Systolic heart Failure	180813	13.77	90352	13.75	90461	13.80
Pre-surgery Evaluation						
Missing or not applicable	1290308	98.27	645880	98.27	644428	98.28
Cardiac Surgery	4145	0.32	2095	0.32	2050	0.31
Non-Cardiac Surgery	18508	1.41	9277	1.41	9231	1.41
Concomitant Procedure without Peripheral Intervention, Peripheral Angiogram, Biopsy of	93713	7.14	46847	7.13	46866	7.15

Description	Total		Validation		Derivation	
	#	%	#	%	#	%
heart, or Procedure Type Not Listed						
Systolic Blood Pressure						
Unknown	6430	0.49	3255	0.50	3175	0.48
Mean (SD)	149.93	25.78	149.98	25.78	149.88	25.78
Decision for PCI with Surgical Consult	70206	5.35	35143	5.35	35063	5.35
Percutaneous Coronary Intervention Indication						
Missing	841	0.06	413	0.06	428	0.07
Stable angina	118155	9.00	59158	9.00	58997	9.00
Primary PCI for Acute STEMI	176622	13.45	88342	13.44	88280	13.46
STEMI - Stable (<12 hours from symptom onset)	1774	0.14	847	0.13	927	0.14
STEMI - Stable (>12 hours from symptom onset)	2826	0.22	1454	0.22	1372	0.21
STEMI - Unstable (>12 hours from symptom onset)	8009	0.61	4026	0.61	3983	0.61
STEMI - (After successful lytics)	3042	0.23	1574	0.24	1468	0.22
STEMI - Rescue (After unsuccessful lytics)	4305	0.33	2139	0.33	2166	0.33
NSTEMI – ACS	489934	37.32	245014	37.28	244920	37.35
Coronary Artery Disease (without ischemic symptoms)	62198	4.74	31109	4.73	31089	4.74
New Onset Angina	111504	8.49	55627	8.46	55877	8.52
Other PCI Indication	333751	25.42	167549	25.49	166202	25.35
At least 1 previously treated lesion within 1 month with in-stent thrombosis	3580	0.27	1793	0.27	1787	0.27
Highest risk lesion -- Segment category						
Other	250370	19.07	125400	19.08	124970	19.06
pRCA/mLAD/pCIRC	734737	55.96	367503	55.92	367234	56.01
pLAD	275289	20.97	138029	21.00	137260	20.93
Left Main	52565	4.00	26320	4.00	26245	4.00
TIMI Flow Pre-Intervention						
Missing	21201	1.61	10655	1.62	10546	1.61
No perfusion	191208	14.56	95650	14.55	95558	14.57
Penetration without perfusion	78664	5.99	39260	5.97	39404	6.01
Partial perfusion	216577	16.50	108333	16.48	108244	16.51
Complete perfusion	805311	61.34	403354	61.37	401957	61.30
Lesion Complexity						

Description	Total		Validation		Derivation	
	#	%	#	%	#	%
Missing	4938	0.38	2530	0.38	2408	0.37
Non-High/Non-C Lesion	434041	33.06	217340	33.07	216701	33.05
High/C Lesion (Dupe)	873982	66.57	437382	66.55	436600	66.58
Post Procedure Bleeding	23169	1.76	11723	1.78	11446	1.75

Values are % or mean (SD).

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LAD = left anterior descending; LVEF = left ventricular ejection fraction; MI = myocardial infarction; NYHA = New York Heart Association; PCI = percutaneous coronary intervention; STEMI= ST-segment elevation myocardial infarction

A summary of these patients' clinical characteristics focused on those predictor variables for those without cardiac arrest/cardiogenic shock are provided under Table 10.

Table 10. Predicted Probability of Bleeding

Description	Overall Cohort			Prob p-value
	N	BLEEDN (Observed)	BLEEDP (Predicted)	
Overall	1312961	23169	1.76	0.0978
STEMI				
No	1116383	16924	1.52	0.0730
Yes	196578	6245	3.18	0.8061
Female				
No	909965	11423	1.26	0.3611
Yes	402996	11746	2.91	0.1888
Age>70				
No	776292	9697	1.25	0.0840
Yes	536669	13472	2.51	0.4572
Clinical Instability (CI)				
Elective PCI and No CI	553310	5167	0.93	0.1575
Urgent PCI and No CI	509393	9259	1.82	0.0699
Emergency PCI and No CI	189448	5480	2.89	0.8443
CI	60428	3260	5.39	0.8574

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5.2.3 Reliability Testing Results

Table 11. Signal to Noise Description

(Table 2 in Battelle application system)

Signal to Noise Analysis:

Signal to Noise analysis for the hospitals is noted under Table 11.

Table 11. Signal to Noise

Description	N	Mean	STD	Min	Max	P1	P99	Q1	Q3	Median	Q range
Among All Hospitals	1704	0.9458	0.0875	0.0555	0.9976	0.5401	0.9946	0.9457	0.9842	0.9722	0.0385

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Split Sample Methodology:

Results from the split sample methodology are available in the Tables and Figures below.

Table 12. Distribution of Risk Standardized Bleeding Rates Stratified by the Randomly Split Samples

Description	Randomly Split Samples	
	First (RAND=1)	Second (RAND=0)
N	1701	1703
Mean	0.0182	0.0186
Std Deviation	0.0063	0.0083
100% Max	0.1624	0.2767
99%	0.0353	0.0379
95%	0.0275	0.0284
90%	0.0247	0.0258
75% Q3	0.0205	0.0209
50% Median	0.0170	0.0174
25% Q1	0.0146	0.0149
10%	0.0126	0.0129
5%	0.0115	0.0116
1%	0.0095	0.0099
0% Min	0.0070	0.0076

Correlation coefficient: 0.70943

ICC: 0.68124

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Figure 6. Distribution of Risk Standardized Bleeding Rates Stratified by the Randomly Split Samples

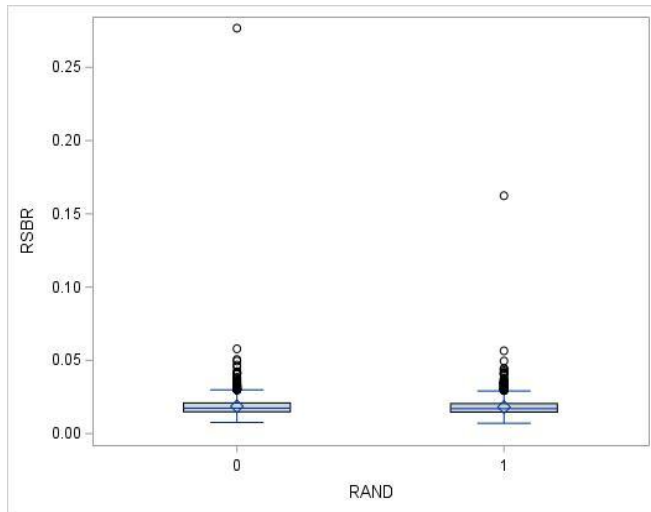
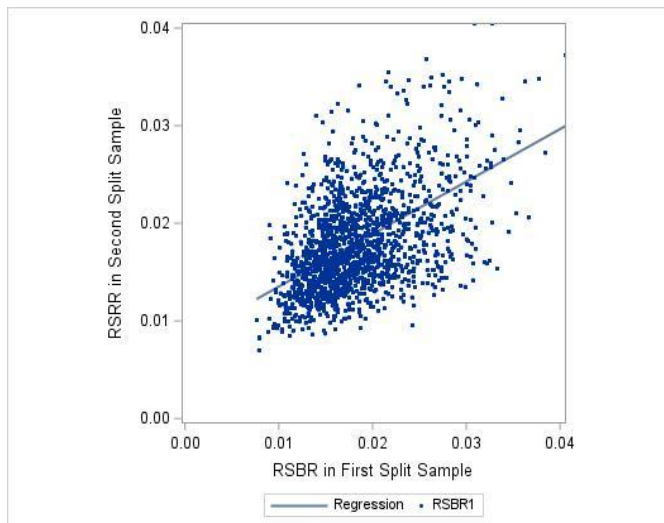


Figure 7. Distribution of Risk Standardized Bleeding Rates Stratified by the Randomly Split Sample Correlation



5.2.4 Interpretation of Reliability Results

Table 13. Accountable Entity Level Reliability Testing Results by Denominator, Target Population Size

*Table 2 on application platform.

	Overall	Min	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10	Max
Reliability	0.9458	0.9886	0.9751	0.9651	0.9507	0.9296	0.8987	0.9170	0.9438	0.9550	0.9586	0.9640	0.9654
Mean Performance Score	0.0186	0.0055	0.0104	0.0128	0.0142	0.0156	0.0169	0.0181	0.0195	0.0215	0.0241	0.0334	0.2668
N of Entities	1704	1	170	170	171	170	171	170	171	170	171	170	1
N of Persons / Encounters / Episodes	1312961	1483	164404	132126	127997	110913	114943	115963	130561	121578	144116	150360	475

*Reliability determined based on signal-to-noise methodology

5.3.4 Validity Testing Results

Below are the results achieved from the empirical validity testing, comparing risk-standardized bleeding rates with in-hospital risk-standardized mortality rates during the same time period (1/2021-12/22):

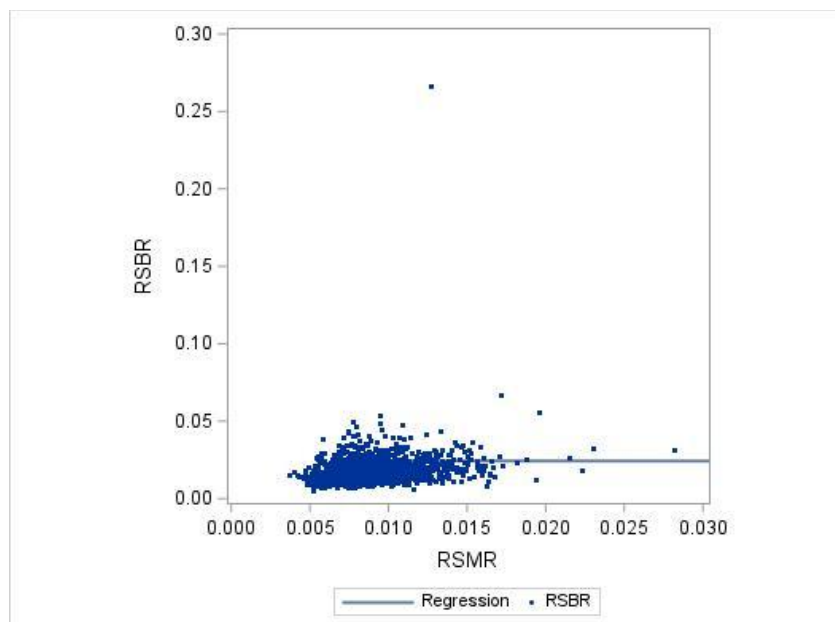
Table 14. Distribution of Performance Rate for Discharge Medications Composite Measure and RSMR (N=1704)

Description	Post Procedure Bleeding Measure		In-Hospital Mortality Measure	
	HVOL	RSBR	HVOL	RSMR
N	1704	1704	1669	1669
Mean	770.52	0.0186	391.93	0.0088
Std Deviation	678.61	0.0087	337.88	0.0024
100% Max	7054	0.2668	3337	0.0282
99%	3126	0.0404	1541	0.0163
95%	2010	0.0298	1000	0.0134
90%	1623	0.0259	803	0.0118
75% Q3	1059	0.0216	541	0.0098
50% Median	595	0.0174	301	0.0083
25% Q1	296.5	0.0143	157	0.0073
10%	136	0.0120	72	0.0064
5%	78	0.0109	44	0.0059
1%	20	0.0086	14	0.0049
0% Min	1	0.0055	2	0.0036

Correlation coefficient: 0.22255

*Empty cells left intentionally blank

Figure 8. Distribution of Mortality Rates by Standardized Bleeding Rates



5.4.3 Variable Distribution Across Measured Entities

The table (16) below includes a description of hospital and patient characteristics. For example, this illustrates that the number of patients that represent diverse race/ethnicity is 21.8%.

Table 16. Selected Characteristics

Description	#	%
ALL	1312961	100.00
Age>=65		
No	523411	39.86
Yes	789550	60.14
Female		
No	909965	69.31
Yes	402996	30.69
RACE		
Hispanic	91946	7.00
White non-Hispanic	1028774	78.36
Black non-Hispanic	110627	8.43
Other	81614	6.22
Medicare		
No	568590	43.31
Yes	744371	56.69
Medicaid		
No	1141219	86.92
Yes	171742	13.08
Dual		
No	1237111	94.22
Yes	75850	5.78
Random Splitting Samples		
First	657252	50.06
Second	655709	49.94
Hospital % Non-White		
Q1 (0.00% to 5.97%)	278341	21.20
Q2 (>5.97% to 14.46%)	369039	28.11
Q3 (>14.46% to 32.24%)	366128	27.89
Q4 (>32.24%)	299453	22.81
Hospital % Dual		
Q1 (0.00%)	262395	19.98
Q2 (>0.00% to 4.37%)	334697	25.49
Q3 (>4.37% to 9.60%)	386075	29.40
Q4 (>9.60%)	329794	25.12
Post Procedure Bleeding		
No	1289792	98.24
Yes	23169	1.76

*Empty cells left intentionally blank