NATIONAL QUALITY FORUM
Driving measurable health improvements together

Measure Information

This document contains the information submitted by measure developers/stewards, but is organized according to NQF's measure evaluation criteria and process. The item numbers refer to those in the submission form but may be in a slightly different order here. In general, the item numbers also reference the related criteria (e.g., item 1b.1 relates to sub criterion 1b).

Brief Measure Information

NQF #: 3686

Corresponding Measures:

Measure Title: Center for Disease Control and Prevention (CDC), National Healthcare Safety Network (NHSN) Hospital-Onset Bacteremia & Fungemia Outcome Measure

Measure Steward: Centers for Disease Control and Prevention

sp.02. Brief Description of Measure: Risk-adjusted ratio of observed bacteremias and fungemias to predicted bacteremias and fungemias among patients previously admitted to acute care hospitals.

1b.01. Developer Rationale: Surveillance for Hospital-Onset Bacteremias and Fungemias (HOB) will help hospitals monitor a broad measure of healthcare-associated infection (HAI) burden and target quality improvement initiatives that reduce many HAI's and thus result in less patient harm, shorter hospitalizations, and lower healthcare costs.

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sp.12. Numerator Statement: Observed bacteremia and fungemia among patients previously admitted to acute care hospitals.

sp.14. Denominator Statement: The HOB measure denominator is the predicted number of HOB events in an acute care hospital based on predictive models using facility-level and patient-level factors.

sp.16. Denominator Exclusions: Not Applicable

Measure Type: Outcome

sp.28. Data Source:

Electronic Health Records

Claims

sp.07. Level of Analysis:

Facility

IF Endorsement Maintenance – Original Endorsement Date:

Most Recent Endorsement Date:

IF this measure is included in a composite, NQF Composite#/title:

IF this measure is paired/grouped, NQF#/title:

sp.03. IF PAIRED/GROUPED, what is the reason this measure must be reported with other measures to appropriately interpret results?:

1. Importance to Measure and Report

Extent to which the specific measure focus is evidence-based, important to making significant gains in healthcare quality, and improving health outcomes for a specific high-priority (high-impact) aspect of healthcare where there is variation in or overall less-than-optimal performance. Measures must be judged to meet all sub criteria to pass this criterion and be evaluated against the remaining criteria

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Please separate added or updated information from the most recent measure evaluation within each question response in the Importance to Measure and Report: Evidence section. For example:

Current Submission:

Updated evidence information here.

Previous (Year) Submission:

Evidence from the previous submission here.

1a.01. Provide a logic model.

Briefly describe the steps between the healthcare structures and processes (e.g., interventions, or services) and the patient's health outcome(s). The relationships in the diagram should be easily understood by general, non-technical audiences. Indicate the structure, process or outcome being measured.

[Response Begins]

Figure 2: Hospital-Onset Bacteremia & Fungemia Measure Logic Model.

[Response Ends]

1a.02. Provide evidence that the target population values the measured outcome, process, or structure and finds it meaningful.

Describe how and from whom input was obtained.

[Response Begins]

HOB serves as a broad measure of HAI burden, which is national priority

HOB serves as a broad, objective measure of Healthcare-associated infection (HAI) burden within a hospital. HAI reduction has been a national priority set by U.S. Government going back to 2008 with the U.S. Health and Human Services (HHS) National Action Plan to Prevent Health Care-associated Infections: Roadmap to Elimination.[1] The 2016 update to this national action plan has included specific HAIs as targets for benchmarking progress: Central-line associated bloodstream infections (CLABSI), and hospital-onset methicillin-resistant *Staphylococcus aureus (HO-MRSA)*. While there has been overall progress in reducing these specific HAIs, there remains a larger body of bloodstream infections that develop during hospitalization that are not attributable to a central line or specifically due to a MRSA pathogen that are associated with significant morbidity but not subject to current surveillance.

Reference

[1]U.S. Health and Human Services (HHS) National Action Plan to Prevent Health Care-associated Infections: Roadmap to Elimination. Accessed July 6, 2022 at https://www.hhs.gov/oidp/topics/health-care-associated-infections/hai-action-plan/index.html

[Response Ends]

1a.03. Provide empirical data demonstrating the relationship between the outcome (or PRO) and at least one healthcare structure, process, intervention, or service.

[Response Begins]

Foundational research has demonstrated that many HOB events occur among patients receiving invasive devices or undergoing surgery during hospitalized care, where evidence-based guidelines for prevention of infections exist.

In a study of 2109 HOB events across 12 hospitals from January 1, 2016-June 30, 2019, 66% of patients with HOB events had central lines, and 28% had undergone surgery in the previous 30 days. [2] The bacteremia or fungemia was attributed to an endovascular source in 32% of HOB events.[2]

Reference

[2] Leeka, S et al. Sources and Preventability of Hospital-onset Bacteremia and Fungemia in the United States: Evaluation of a Potential Healthcare Quality Measure. Presentation at IDWeek 2022 October 19, 2022.

[Response Ends]

1b.01. Briefly explain the rationale for this measure.

Explain how the measure will improve the quality of care, and list the benefits or improvements in quality envisioned by use of this measure.

[Response Begins]

Surveillance for Hospital-Onset Bacteremias and Fungemias (HOB) will help hospitals monitor a broad measure of healthcare-associated infection (HAI) burden and target quality improvement initiatives that reduce many HAI's and thus result in less patient harm, shorter hospitalizations, and lower healthcare costs.

[Response Ends]

1b.02. Provide performance scores on the measure as specified (current and over time) at the specified level of analysis.

Include mean, std dev, min, max, interquartile range, and scores by decile. Describe the data source including number of measured entities; number of patients; dates of data; if a sample, characteristics of the entities include. This information also will be used to address the sub-criterion on improvement (4b) under Usability and Use.

[Response Begins]

Because HOB is a new measure, data on prospective use of HOB as a quality measure is not available. However a recent retrospective study of HOB performance has demonstrated variability in HOB measure levels across a large sample of hospitals, indicating an opportunity to improve practices and reduce HOB events.[3]

Variability in HOB performance was demonstrated in a study of electronic microbiological, medication and administrative data from 9,202,650 admissions of adult patients 18 years or older admitted from October 1, 2015, through February 28, 2020 to one of 267 acute care hospitals within the Becton Dickinson Insights and Research Database (Becton, Dickinson and Company, Franklin Lakes, NJ).[3]

Specifically:

1. Unadjusted HOB rates significantly varied across the 267 hospitals even when stratified by many hospital-level factors, blood culture testing practices, community-onset bacteremia & fungemia prevalence, and patient population-level factors. (Table 1).
2. Risk-adjusted Hospital-level Standardized Infection Ratios (SIR), or Observed / Expected ratios were calculated using a negative binomial regression model accounting for risk factors for HOB. This resulted in a risk-adjusted SIR for each of the 267 hospitals which can be used to rank the hospitals by quartiles.

Table 1: Descriptive Statistics of HOB Rate and Bivariate Analysis Results Among 9,202,650 admissions in 267 hospitals from 2015-2020.

Variables	**Admissions**	**HOB events**	**HOB rate per 100 admissions**	**-**	**-**	**-**	**-**	**-**
-	-	-	**Lower Quartile**	**Median**	**Upper Quartile**	**Mean**	**SD**	**P value**
Overall	9,202,650	18,747	0.000	0.124	0.222	0.152	0.171	-
Year	-	-	-	-	-	-	-	0.1108
2015	345,954	844	0.052	0.140	0.250	0.175	0.168	-
2016	1,719,915	3,741	0.000	0.128	0.234	0.160	0.174	-
2017	2,049,727	3,953	0.027	0.126	0.213	0.147	0.152	-
2018	2,314,695	4,498	0.000	0.121	0.218	0.147	0.163	-
2019	2,265,115	4,585	0.000	0.121	0.221	0.151	0.190	-
2020	507,244	1,126	0.000	0.124	0.230	0.156	0.161	-
COB rate per 100 admissions	-	-	-	-	-	-	-	<0.0001
1st quartile	2,106,482	3,026	0.000	0.049	0.144	0.098	0.148	-

Variables	Admissions	HOB events	HOB rate per 100 admissions	-	-	-	-	-
2nd quartile	2,726,188	5,512	0.067	0.140	0.229	0.162	0.140	-
3rd quartile	2,516,053	6,190	0.070	0.153	0.254	0.185	0.185	-
4th quartile	1,853,927	4,019	0.000	0.140	0.234	0.163	0.191	-
% ICU admissions	-	-	-	-	-	-	-	<0.0001
Not reported	391,894	1,176	0.000	0.097	0.246	0.207	0.326	-
1st quartile	1,604,752	2,268	0.000	0.063	0.154	0.099	0.154	-
2nd quartile	2,639,107	4,113	0.071	0.137	0.208	0.149	0.112	-
3rd quartile	2,283,445	4,838	0.047	0.137	0.240	0.159	0.144	-
4th quartile	2,283,452	6,352	0.000	0.156	0.271	0.181	0.167	-
Test prevalence	-	-	-	-	-	-	-	<0.0001
1st quartile	2,539,201	4,005	0.000	0.084	0.185	0.118	0.130	-
2nd quartile	2,570,229	4,899	0.053	0.138	0.219	0.152	0.133	-
3rd quartile	2,533,628	6,268	0.074	0.160	0.255	0.188	0.180	-
4th quartile	1,559,592	3,575	0.000	0.109	0.212	0.150	0.217	-
CO testing prevalence	-	-	-	-	-	-	-	0.1907
1st quartile	2,647,568	4,314	0.000	0.096	0.196	0.125	0.136	-
2nd quartile	2,688,690	6,010	0.062	0.145	0.241	0.183	0.215	-
3rd quartile	2,458,568	5,860	0.070	0.159	0.253	0.182	0.166	-
4th quartile	1,407,824	2,563	0.000	0.087	0.182	0.118	0.143	-
HO testing prevalence	-	-	-	-	-	-	-	<0.0001
1st quartile	1,492,842	1,769	0.000	0.000	0.090	0.060	0.110	-
2nd quartile	1,983,166	2,440	0.000	0.085	0.155	0.102	0.105	-
3rd quartile	2,435,148	4,349	0.086	0.150	0.225	0.161	0.115	-
4th quartile	3,291,494	10,189	0.157	0.245	0.354	0.284	0.227	-
Test intensity	-	-	-	-	-	-	-	<0.0001
Not calculated[a]	2,009	0	0.000	0.000	0.000	0.000	0.000	-
1st quartile	1,344,262	2,329	0.000	0.000	0.131	0.083	0.166	-
2nd quartile	1,831,097	2,602	0.000	0.093	0.172	0.111	0.113	-
3rd quartile	2,588,338	4,551	0.080	0.148	0.227	0.160	0.112	-
4th quartile	3,436,944	9,265	0.127	0.217	0.333	0.256	0.216	-
CO testing intensity	-	-	-	-	-	-	-	<0.0001

Variables	Admissions	HOB events	HOB rate per 100 admissions	-	-	-	-	-
Not calculated[a]	2,009	0	0.000	0.000	0.000	0.000	0.000	-
1st quartile	2,553,321	7,138	0.000	0.155	0.288	0.20	0.239	-
2nd quartile	2,595,848	5,248	0.048	0.139	0.238	0.16	0.141	-
3rd quartile	2,070,811	3,050	0.000	0.098	0.183	0.12	0.124	-
4th quartile	1,980,661	3,311	0.000	0.110	0.203	0.13	0.144	-
HO testing intensity	-	-	-	-	-	-	-	<0.0001
Not calculated[a]	2,009	0	0.000	0.000	0.000	0.000	0.000	-
1st quartile	754,629	448	0.000	0.000	0.068	0.05	0.095	-
2nd quartile	1,762,768	2,074	0.000	0.097	0.159	0.11	0.112	-
3rd quartile	2,821,882	4,717	0.087	0.151	0.223	0.16	0.105	-
4th quartile	3,861,362	11,508	0.163	0.256	0.366	0.29	0.226	-
Average LOS	-	-	-	-	-	-	-	<0.0001
1st quartile	986,567	900	0.000	0.000	0.118	0.069	0.106	-
2nd quartile	2,228,773	3,070	0.046	0.115	0.184	0.125	0.115	-
3rd quartile	2,812,385	4,787	0.071	0.142	0.225	0.155	0.115	-
4th quartile	3,174,925	9,990	0.105	0.230	0.354	0.259	0.245	-
% female	-	-	-	-	-	-	-	<0.0001
1st quartile	2,558,016	7,124	0.078	0.173	0.305	0.220	0.237	-
2nd quartile	2,750,286	5,687	0.044	0.134	0.238	0.156	0.140	-
3rd quartile	2,344,363	3,770	0.000	0.117	0.192	0.133	0.131	-
4th quartile	1,549,985	2,166	0.000	0.072	0.164	0.098	0.125	-
% patients with age 18-40 years	-	-	-	-	-	-	-	0.3053
1st quartile	1,441,315	2,895	0.000	0.083	0.213	0.145	0.238	-
2nd quartile	2,527,501	4,340	0.056	0.131	0.209	0.143	0.119	-
3rd quartile	3,043,248	6,505	0.068	0.146	0.246	0.168	0.137	-
4th quartile	2,190,586	5,007	0.000	0.111	0.226	0.152	0.163	-
% patients with age 41-64 years	-	-	-	-	-	-	-	<0.0001
1st quartile	1,485,852	2,032	0.000	0.060	0.159	0.096	0.148	-
2nd quartile	2,353,286	3,463	0.041	0.124	0.196	0.134	0.120	-
3rd quartile	2,389,590	4,116	0.044	0.129	0.207	0.142	0.128	-
4th quartile	2,973,922	9,136	0.067	0.204	0.347	0.236	0.231	-

Variables	Admissions	HOB events	HOB rate per 100 admissions	-	-	-	-	-
% patients with age 65-80 years	-	-	-	-	-	-	-	<0.0001
1st quartile	2,303,940	5,775	0.000	0.131	0.261	0.170	0.170	-
2nd quartile	2,619,330	5,123	0.040	0.134	0.225	0.148	0.132	-
3rd quartile	2,641,306	4,779	0.041	0.128	0.214	0.142	0.126	-
4th quartile	1,638,074	3,070	0.000	0.100	0.209	0.147	0.233	-
% patients with age >80 years	-	-	-	-	-	-	-	<0.0001
1st quartile	2,980,076	8,973	0.060	0.176	0.338	0.227	0.230	-
2nd quartile	2,512,598	4,295	0.052	0.133	0.220	0.145	0.118	-
3rd quartile	2,248,231	3,288	0.000	0.116	0.191	0.128	0.147	-
4th quartile	1,461,745	2,191	0.000	0.073	0.178	0.108	0.141	-
Bed size (3-category)	-	-	-	-	-	-	-	<0.0001
< 100	597,381	484	0.000	0.000	0.108	0.069	0.161	-
100-300	3,374,473	5,606	0.055	0.128	0.216	0.157	0.170	-
> 300	5,230,796	12,657	0.127	0.201	0.301	0.227	0.141	-
Bed size (refined grouping)	-	-	-	-	-	-	-	<0.0001
1-50	147,420	78	0.000	0.000	0.000	0.054	0.200	-
51-100	449,961	406	0.000	0.000	0.144	0.085	0.109	-
101-200	1,395,467	1,889	0.000	0.106	0.186	0.129	0.129	-
201-300	1,979,006	3,717	0.085	0.151	0.242	0.193	0.205	-
301-500	3,051,740	5,877	0.113	0.168	0.252	0.196	0.127	-
500+	2,179,056	6,780	0.201	0.285	0.379	0.300	0.147	-
Medical school affiliation	-	-	-	-	-	-	-	<0.0001
No	3,246,090	4,823	0.000	0.077	0.176	0.108	0.144	-
Yes	5,956,560	13,924	0.097	0.168	0.282	0.212	0.185	-
Urban/rural	-	-	-	-	-	-	-	<0.0001
Rural	2,401,605	4,230	0.000	0.073	0.185	0.119	0.174	-
Urban	6,801,045	14,517	0.059	0.143	0.242	0.170	0.166	-

Table 1 compares admissions, HOB events, HOB rate per 100 admissions in the lower quartile, median, upper quartile, mean, SD, and P value by the specific variables. Refer to the text preceding the table for more details.

Abbreviations: - cell left intentionally empty. CO, community-onset; COB, community-onset bacteremia; HO, hospital-onset; HOB, hospital-onset bacteremia; ICU, intensive care unit; LOS, length of stay; SD, standard deviation.

[a]Due to zero denominator

Table 2. Parameters used to calculate HOB Standardized Infection Ratios using data from 9,202,650 admissions in 267 hospitals from 2015-2020.

Parameter	Estimate	Standard Error	P
Intercept	-3.115	0.073	<0.0001
COB rate per 100 admissions	-	-	-
1st quartile	-	-	reference
2nd quartile	0.221	0.032	<0.0001
3rd quartile	0.366	0.033	<0.0001
4th quartile	0.416	0.038	<0.0001
HO test intensity	-	-	-
1st quartile	-	-	reference
2nd quartile	0.455	0.057	<0.0001
3rd quartile	0.658	0.059	<0.0001
4th quartile	0.869	0.061	<0.0001
CO test intensity	-	-	-
1st quartile	-	-	reference
2nd quartile	-0.188	0.027	<0.0001
3rd quartile	-0.271	0.032	<0.0001
4th quartile	-0.295	0.032	<0.0001
HO test prevalence	-	-	-
< 2nd quartile	-	-	reference
3rd quartile	0.222	0.031	<0.0001
4th quartile	0.327	0.034	<0.0001
%ICU admissions	-	-	-
≤ 3rd quartile	-	-	reference
4th quartile	0.100	0.025	<0.0001
Not reported	0.474	0.042	<0.0001
Mean LOS	-	-	-
≤ 3rd quartile	-	-	reference
4th quartile	0.140	0.026	<0.0001
Bed size	-	-	-
01-100	-	-	reference
101-200	0.225	0.055	<0.0001
201-300	0.396	0.055	<0.0001
301-500	0.358	0.054	<0.0001

Parameter	Estimate	Standard Error	P
500+	0.351	0.057	<0.0001
% of patients aged 41-64 years	-	-	
1st quartile	-	-	reference
2nd quartile	0.111	0.035	0.0015
3rd quartile	0.141	0.036	<0.0001
4th quartile	0.325	0.038	<0.0001
% of patients aged >80 years	-	-	-
1st quartile	-	-	reference
2nd quartile	-0.175	0.029	<0.0001
3rd quartile	-0.234	0.033	<0.0001
4th quartile	-0.183	0.038	<0.0001

Table 2 describes parameter estimates, standard errors, and p values of parameters used to calculate HOB Standardized Infection Ratios . Refer to the text preceding the table for more details.

Abbreviations: - cell left intentionally blank, CO, community-onset; COB, community-onset bacteremia; HO, hospital-onset; HOB, hospital-onset bacteremia; ICU, intensive care unit; LOS, length of stay.

[a]Goodness-of-fit statistics: Akaike's Information Criteria = 12,882, Bayesian Information Criteria = 13,042.

Reference

[3] Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. Infection Control & Hospital Epidemiology, 1-9. doi:10.1017/ice.2022.211

[Response Ends]

1b.03. If no or limited performance data on the measure as specified is reported above, then provide a summary of data from the literature that indicates opportunity for improvement or overall less than optimal performance on the specific focus of measurement. Include citations.

[Response Begins]

Research from a recent peer-reviewed manuscript has demonstrated variability in HOB measure levels across a large sample of hospitals, indicating an opportunity to improve practices and reduce HOB events.[3]

Variability in HOB performance was demonstrated in a study of electronic microbiological, medication and administrative data from 9,202,650 admissions of adult patients 18 years or older admitted from October 1, 2015, through February 28, 2020 to one of 267 acute care hospitals within the Becton Dickinson Insights and Research Database (Becton, Dickinson and Company, Franklin Lakes, NJ). [3]

Specifically:

1. Unadjusted HOB rates significantly varied across the 267 hospitals even when stratified by many hospital-level factors, blood culture testing practices, community-onset bacteremia & fungemia prevalence, and patient population-level factors. (Table 1).
2. Risk-adjusted Hospital-level Standardized Infection Ratios (SIR), or Observed / Expected ratios were calculated using a negative binomial regression model accounting for risk factors for HOB. This resulted in a risk-adjusted SIR for each of the 267 hospitals which can be used to rank the hospitals by quartiles.

Table 1: Descriptive Statistics of HOB Rate and Bivariate Analysis Results Among 9,202,650 admissions in 267 hospitals from 2015-2020.

Variables	Admissions	HOB events	HOB rate per 100 admissions	-	-	-	-	-
-	-	-	Lower Quartile	Median	Upper Quartile	Mean	SD	P value
Overall	9,202,650	18,747	0.000	0.124	0.222	0.152	0.171	-
Year	-	-	-	-	-	-	-	0.1108
2015	345,954	844	0.052	0.140	0.250	0.175	0.168	-
2016	1,719,915	3,741	0.000	0.128	0.234	0.160	0.174	-
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COB rate per 100 admissions	-	-	-	-	-	-	-	<0.0001
1st quartile	2,106,482	3,026	0.000	0.049	0.144	0.098	0.148	-
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3rd quartile	2,516,053	6,190	0.070	0.153	0.254	0.185	0.185	-
4th quartile	1,853,927	4,019	0.000	0.140	0.234	0.163	0.191	-
% ICU admissions	-	-	-	-	-	-	-	<0.0001
Not reported	391,894	1,176	0.000	0.097	0.246	0.207	0.326	-
1st quartile	1,604,752	2,268	0.000	0.063	0.154	0.099	0.154	-
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4th quartile	2,283,452	6,352	0.000	0.156	0.271	0.181	0.167	-
Test prevalence	-	-	-	-	-	-	-	<0.0001
1st quartile	2,539,201	4,005	0.000	0.084	0.185	0.118	0.130	-
2nd quartile	2,570,229	4,899	0.053	0.138	0.219	0.152	0.133	-
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4th quartile	1,559,592	3,575	0.000	0.109	0.212	0.150	0.217	-
CO testing prevalence	-	-	-	-	-	-	-	0.1907
1st quartile	2,647,568	4,314	0.000	0.096	0.196	0.125	0.136	-
2nd quartile	2,688,690	6,010	0.062	0.145	0.241	0.183	0.215	-
3rd quartile	2,458,568	5,860	0.070	0.159	0.253	0.182	0.166	-
4th quartile	1,407,824	2,563	0.000	0.087	0.182	0.118	0.143	-
HO testing prevalence	-	-	-	-	-	-	-	<0.0001

Variables	Admissions	HOB events	HOB rate per 100 admissions	-	-	-	-	-
1st quartile	1,492,842	1,769	0.000	0.000	0.090	0.060	0.110	-
2nd quartile	1,983,166	2,440	0.000	0.085	0.155	0.102	0.105	-
3rd quartile	2,435,148	4,349	0.086	0.150	0.225	0.161	0.115	-
4th quartile	3,291,494	10,189	0.157	0.245	0.354	0.284	0.227	-
Test intensity	-	-	-	-	-	-	-	<0.0001
Not calculated[a]	2,009	0	0.000	0.000	0.000	0.000	0.000	-
1st quartile	1,344,262	2,329	0.000	0.000	0.131	0.083	0.166	-
2nd quartile	1,831,097	2,602	0.000	0.093	0.172	0.111	0.113	-
3rd quartile	2,588,338	4,551	0.080	0.148	0.227	0.160	0.112	-
4th quartile	3,436,944	9,265	0.127	0.217	0.333	0.256	0.216	-
CO testing intensity	-	-	-	-	-	-	-	<0.0001
Not calculated[a]	2,009	0	0.000	0.000	0.000	0.000	0.000	-
1st quartile	2,553,321	7,138	0.000	0.155	0.288	0.20	0.239	-
2nd quartile	2,595,848	5,248	0.048	0.139	0.238	0.16	0.141	-
3rd quartile	2,070,811	3,050	0.000	0.098	0.183	0.12	0.124	-
4th quartile	1,980,661	3,311	0.000	0.110	0.203	0.13	0.144	-
HO testing intensity	-	-	-	-	-	-	-	<0.0001
Not calculated[a]	2,009	0	0.000	0.000	0.000	0.000	0.000	-
1st quartile	754,629	448	0.000	0.000	0.068	0.05	0.095	-
2nd quartile	1,762,768	2,074	0.000	0.097	0.159	0.11	0.112	-
3rd quartile	2,821,882	4,717	0.087	0.151	0.223	0.16	0.105	-
4th quartile	3,861,362	11,508	0.163	0.256	0.366	0.29	0.226	-
Average LOS	-	-	-	-	-	-	-	<0.0001
1st quartile	986,567	900	0.000	0.000	0.118	0.069	0.106	-
2nd quartile	2,228,773	3,070	0.046	0.115	0.184	0.125	0.115	-
3rd quartile	2,812,385	4,787	0.071	0.142	0.225	0.155	0.115	-
4th quartile	3,174,925	9,990	0.105	0.230	0.354	0.259	0.245	-
% female	-	-	-	-	-	-	-	<0.0001
1st quartile	2,558,016	7,124	0.078	0.173	0.305	0.220	0.237	-
2nd quartile	2,750,286	5,687	0.044	0.134	0.238	0.156	0.140	-
3rd quartile	2,344,363	3,770	0.000	0.117	0.192	0.133	0.131	-
4th quartile	1,549,985	2,166	0.000	0.072	0.164	0.098	0.125	-

Variables	Admissions	HOB events	HOB rate per 100 admissions	-	-	-	-	-
% patients with age 18-40 years	-	-	-	-	-	-	-	0.3053
1st quartile	1,441,315	2,895	0.000	0.083	0.213	0.145	0.238	-
2nd quartile	2,527,501	4,340	0.056	0.131	0.209	0.143	0.119	-
3rd quartile	3,043,248	6,505	0.068	0.146	0.246	0.168	0.137	-
4th quartile	2,190,586	5,007	0.000	0.111	0.226	0.152	0.163	-
% patients with age 41-64 years	-	-	-	-	-	-	-	<0.0001
1st quartile	1,485,852	2,032	0.000	0.060	0.159	0.096	0.148	-
2nd quartile	2,353,286	3,463	0.041	0.124	0.196	0.134	0.120	-
3rd quartile	2,389,590	4,116	0.044	0.129	0.207	0.142	0.128	-
4th quartile	2,973,922	9,136	0.067	0.204	0.347	0.236	0.231	-
% patients with age 65-80 years	-	-	-	-	-	-	-	<0.0001
1st quartile	2,303,940	5,775	0.000	0.131	0.261	0.170	0.170	-
2nd quartile	2,619,330	5,123	0.040	0.134	0.225	0.148	0.132	-
3rd quartile	2,641,306	4,779	0.041	0.128	0.214	0.142	0.126	-
4th quartile	1,638,074	3,070	0.000	0.100	0.209	0.147	0.233	-
% patients with age >80 years	-	-	-	-	-	-	-	<0.0001
1st quartile	2,980,076	8,973	0.060	0.176	0.338	0.227	0.230	-
2nd quartile	2,512,598	4,295	0.052	0.133	0.220	0.145	0.118	-
3rd quartile	2,248,231	3,288	0.000	0.116	0.191	0.128	0.147	-
4th quartile	1,461,745	2,191	0.000	0.073	0.178	0.108	0.141	-
Bed size (3-category)	-	-	-	-	-	-	-	<0.0001
< 100	597,381	484	0.000	0.000	0.108	0.069	0.161	-
100-300	3,374,473	5,606	0.055	0.128	0.216	0.157	0.170	-
> 300	5,230,796	12,657	0.127	0.201	0.301	0.227	0.141	-
Bed size (refined grouping)	-	-	-	-	-	-	-	<0.0001
1-50	147,420	78	0.000	0.000	0.000	0.054	0.200	-
51-100	449,961	406	0.000	0.000	0.144	0.085	0.109	-
101-200	1,395,467	1,889	0.000	0.106	0.186	0.129	0.129	-

Variables	Admissions	HOB events	HOB rate per 100 admissions	-	-	-	-	-
201-300	1,979,006	3,717	0.085	0.151	0.242	0.193	0.205	-
301-500	3,051,740	5,877	0.113	0.168	0.252	0.196	0.127	-
500+	2,179,056	6,780	0.201	0.285	0.379	0.300	0.147	-
Medical school affiliation	-	-	-	-	-	-	-	<0.0001
No	3,246,090	4,823	0.000	0.077	0.176	0.108	0.144	-
Yes	5,956,560	13,924	0.097	0.168	0.282	0.212	0.185	-
Urban/rural	-	-	-	-	-	-	-	<0.0001
Rural	2,401,605	4,230	0.000	0.073	0.185	0.119	0.174	-
Urban	6,801,045	14,517	0.059	0.143	0.242	0.170	0.166	-

Table 1 compares admissions, HOB events, HOB rate per 100 admissions in the lower quartile, median, upper quartile, mean, SD, and P value by the specific variables. Refer to the text preceding the table for more details.

Abbreviations: - cell left intentionally blank, CO, community-onset; COB, community-onset bacteremia; HO, hospital-onset; HOB, hospital-onset bacteremia; ICU, intensive care unit; LOS, length of stay; SD, standard deviation.

[a]Due to zero denominator

Table 2. Parameters used to calculate HOB Standardized Infection Ratios using data from 9,202,650 admissions in 267 hospitals from 2015-2020.

Parameter	Estimate	Standard Error	P
Intercept	-3.115	0.073	<0.0001
COB rate per 100 admissions	-	-	-
1st quartile	-	-	reference
2nd quartile	0.221	0.032	<0.0001
3rd quartile	0.366	0.033	<0.0001
4th quartile	0.416	0.038	<0.0001
HO test intensity	-	-	-
1st quartile	-	-	reference
2nd quartile	0.455	0.057	<0.0001
3rd quartile	0.658	0.059	<0.0001
4th quartile	0.869	0.061	<0.0001
CO test intensity	-	-	-
1st quartile	-	-	reference
2nd quartile	-0.188	0.027	<0.0001
3rd quartile	-0.271	0.032	<0.0001
4th quartile	-0.295	0.032	<0.0001
HO test prevalence	-	-	-
< 2nd quartile	-	-	reference

Parameter	Estimate	Standard Error	P
3rd quartile	0.222	0.031	<0.0001
4th quartile	0.327	0.034	<0.0001
%ICU admissions	-	-	-
≤ 3rd quartile	-	-	reference
4th quartile	0.100	0.025	<0.0001
Not reported	0.474	0.042	<0.0001
Mean LOS	-	-	-
≤ 3rd quartile	-	-	reference
4th quartile	0.140	0.026	<0.0001
Bed size	-	-	-
01-100	-	-	reference
101-200	0.225	0.055	<0.0001
201-300	0.396	0.055	<0.0001
301-500	0.358	0.054	<0.0001
500+	0.351	0.057	<0.0001
% of patients aged 41-64 years	-	-	
1st quartile	-	-	reference
2nd quartile	0.111	0.035	0.0015
3rd quartile	0.141	0.036	<0.0001
4th quartile	0.325	0.038	<0.0001
% of patients aged >80 years	-	-	-
1st quartile	-	-	reference
2nd quartile	-0.175	0.029	<0.0001
3rd quartile	-0.234	0.033	<0.0001
4th quartile	-0.183	0.038	<0.0001

Table 2 describes parameter estimates, standard errors, and p values of parameters used to calculate HOB Standardized Infection Ratios . Refer to the text preceding the table for more details.

Abbreviations: - cell left intentionally blank, CO, community-onset; COB, community-onset bacteremia; HO, hospital-onset; HOB, hospital-onset bacteremia; ICU, intensive care unit; LOS, length of stay.

[a]Goodness-of-fit statistics: Akaike's Information Criteria = 12,882, Bayesian Information Criteria = 13,042.

Reference

[3] Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. Infection Control & Hospital Epidemiology, 1-9. doi:10.1017/ice.2022.211

[Response Ends]

1b.04. Provide disparities data from the measure as specified (current and over time) by population group, e.g., by race/ethnicity, gender, age, insurance status, socioeconomic status, and/or disability.

Describe the data source including number of measured entities; number of patients; dates of data; if a sample, characteristics of the entities included. Include mean, std dev, min, max, interquartile range, and scores by decile. For measures that show high levels of performance, i.e., "topped out", disparities data may demonstrate an opportunity for improvement/gap in care for certain sub-populations. This information also will be used to address the sub-criterion on improvement (4b) under Usability and Use.

[Response Begins]

In order to identify disparities among patients with HOB events, we compared demographics of patients with HOB events to three comparison groups in an analysis of the Premier Healthcare Database, which included 10,092,282 hospitalizations in 260 hospitals from January 1, 2012-December 31, 2017.

Comparison to Patients with Negative Blood Cultures or Present on Admission Bacteremia & Fungemia

When compared to hospitalized patients with negative blood cultures and those with bacteremia or fungemia that was present on admission, patients with HOB were slightly younger (Mean age 62.8 years vs. 63.9 years, and 65.4 years, respectively), and slightly more likely to be black (19.3% vs. 17.7% and 16.9%, respectively).

Comparison to All Hospitalized Patients in the Premier Healthcare Database

When compared to all hospitalizations from the same time period in the Premier Healthcare Database, patients with HOB events were older (Mean age 62.8 years vs. 49.9 years), with a higher proportion of HOB events occurring among males (55% vs. 42%), black patients (19% vs. 15.2%), slightly less often among Hispanic patients (4% vs. 5.3%).

Comparison to U.S. Census Data

When compared to 2020 US Census Data, a higher proportion of HOB events occurred among males (55% vs. 50%), and Black or African American Alone or in Combination individuals (20% vs. 14%).[4] The proportion of HOB events among Hispanic patients (4%) was much lower in comparison to 2020 U.S. Census data (18.7% Hispanic or Latino).[5]

This analysis has not yet been published.

References:

[4] US Census 2020 data, accessed June 20, 2022: https://www.census.gov/library/visualizations/interactive/race-and-ethnicity-in-the-united-state-2010-and-2020-census.html

[5] US Census 2020 data, accessed June 20, 2022: https://www2.census.gov/programs-surveys/popest/tables/2020/2020-demographic-analysis-estimates/table-1.xlsx

[Response Ends]

1b.05. If no or limited data on disparities from the measure as specified is reported above, then provide a summary of data from the literature that addresses disparities in care on the specific focus of measurement. Include citations. Not necessary if performance data provided in above.

[Response Begins]

Not Applicable.

[Response Ends]

2. Scientific Acceptability of Measure Properties

Extent to which the measure, as specified, produces consistent (reliable) and credible (valid) results about the quality of care when implemented. Measures must be judged to meet the sub criteria for both reliability and validity to pass this criterion and be evaluated against the remaining criteria.

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sp.01. Provide the measure title.

Measure titles should be concise yet convey who and what is being measured (see What Good Looks Like).

[Response Begins]

Center for Disease Control and Prevention (CDC), National Healthcare Safety Network (NHSN) Hospital-Onset Bacteremia & Fungemia Outcome Measure

[Response Ends]

sp.02. Provide a brief description of the measure.

Including type of score, measure focus, target population, timeframe, (e.g., Percentage of adult patients aged 18-75 years receiving one or more HbA1c tests per year).

[Response Begins]

Risk-adjusted ratio of observed bacteremias and fungemias to predicted bacteremias and fungemias among patients previously admitted to acute care hospitals.

[Response Ends]

sp.04. Check all the clinical condition/topic areas that apply to your measure, below.

Please refrain from selecting the following answer option(s). We are in the process of phasing out these answer options and request that you instead select one of the other answer options as they apply to your measure.

Please do not select:

- *Surgery: General*

[Response Begins]

Infectious Diseases (ID)

[Response Ends]

sp.05. Check all the non-condition specific measure domain areas that apply to your measure, below.

[Response Begins]

Safety: Healthcare Associated Infections

[Response Ends]

sp.06. Select one or more target population categories.

Select only those target populations which can be stratified in the reporting of the measure's result.

Please refrain from selecting the following answer option(s). We are in the process of phasing out these answer options and request that you instead select one of the other answer options as they apply to your measure.

Please do not select:

- *Populations at Risk: Populations at Risk*

[Response Begins]

Adults (Age >= 18)

Children (Age < 18)

[Response Ends]

sp.07. Select the levels of analysis that apply to your measure.

Check ONLY the levels of analysis for which the measure is SPECIFIED and TESTED.

Please refrain from selecting the following answer option(s). We are in the process of phasing out these answer options and request that you instead select one of the other answer options as they apply to your measure.

Please do not select:

- *Clinician: Clinician*
- *Population: Population*

[Response Begins]

Facility

[Response Ends]

sp.08. Indicate the care settings that apply to your measure.

Check ONLY the settings for which the measure is SPECIFIED and TESTED.

[Response Begins]

Inpatient/Hospital

[Response Ends]

sp.09. Provide a URL link to a web page specific for this measure that contains current detailed specifications including code lists, risk model details, and supplemental materials.

Do not enter a URL linking to a home page or to general information. If no URL is available, indicate "none available".

[Response Begins]

None currently available. Will be made available on the CDC NHSN website once the new module goes live.

[Response Ends]

sp.12. Attach the data dictionary, code table, or value sets (and risk model codes and coefficients when applicable). Excel formats (.xlsx or .csv) are preferred.

Attach an excel or csv file; if this poses an issue, contact staff. Provide descriptors for any codes. Use one file with multiple worksheets, if needed.

[Response Begins]

Available in attached Excel or csv file

[Response Ends]

Attachment: 3686_3686_HOB Data Elements-508.xlsx

For the question below: state the outcome being measured. Calculation of the risk-adjusted outcome should be described in sp.22.

sp.13. State the numerator.

Brief, narrative description of the measure focus or what is being measured about the target population, i.e., cases from the target population with the target process, condition, event, or outcome).

DO NOT include the rationale for the measure.

[Response Begins]

Observed bacteremia and fungemia among patients previously admitted to acute care hospitals.

[Response Ends]

For the question below: describe how the observed outcome is identified/counted. Calculation of the risk-adjusted outcome should be described in sp.22.

sp.14. Provide details needed to calculate the numerator.

All information required to identify and calculate the cases from the target population with the target process, condition, event, or outcome such as definitions, time period for data collection, specific data collection items/responses, code/value sets.

Note: lists of individual codes with descriptors that exceed 1 page should be provided in an Excel or csv file in required format at sp.11.

[Response Begins]

Hospital-Onset Bacteremia & Fungemia (HOB) Event

An HOB event occurs when a patient has a recognized bacterial or fungal pathogen from a blood specimen collected on the 4th calendar day of admission or later (where the date of admission to an inpatient location is calendar day 1).

The pathogen must NOT be included on the National Healthcare Safety Network common commensal list, and is further subject to the numerator exclusions below:

HOB Event Exclusions:

Previous matching Present on Admission Bacteremia or Fungemia: If a blood culture demonstrates growth of a pathogenic bacteria or fungi after hospital day 4 but also had a pathogen matching to the same species or genus level identified from a blood specimen by culture that was collected prior to hospital day 4 (where calendar date of admission to an inpatient location is day 1) and up to 2 calendar days prior to admission, then this bacteremia or fungemia is NOT considered an HOB event.

If multiple pathogens are identified from the same blood culture, then a match of any of those pathogens to a blood pathogen from a blood culture collected prior to hospital day 4 and up to 2 calendar days prior to admission is sufficient to exclude the event from the HOB measure.

Previous HOB event: A patient with a previous HOB event is excluded from additional HOB events during the same inpatient admission.

[Response Ends]

For the question below: state the target population for the outcome. Calculation of the risk-adjusted outcome should be described in sp.22.

sp.15. State the denominator.

Brief, narrative description of the target population being measured.

[Response Begins]

The HOB measure denominator is the predicted number of HOB events in an acute care hospital based on predictive models using facility-level and patient-level factors.

[Response Ends]

For the question below: describe how the target population is identified. Calculation of the risk-adjusted outcome should be described in sp.22.

sp.16. Provide details needed to calculate the denominator.

All information required to identify and calculate the target population/denominator such as definitions, time period for data collection, specific data collection items/responses, code/value sets.

Note: lists of individual codes with descriptors that exceed 1 page should be provided in an Excel or csv file in required format at sp.11.

[Response Begins]

The HOB measure denominator is the predicted number of HOB events in an acute care hospital based on predictive models using facility-level and patient-level factors. NHSN uses negative binomial regression models when estimating incidence from a summarized population, using methods which have been previously described and are used to create Standardized Infection Ratios (SIR) for many healthcare-associated infections: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/nhsn-sir-guide.pdf

Exploratory scientific studies and prior experience with predictive models of other healthcare-associated infections have identified several candidate variables that may be included in predictive models, which are summarized below:

Predicted HOB Events (Non-Neonatal Intensive Care Unit)

The following are a list of variables to be analyzed in risk adjustment for settings other than the neonatal intensive care unit:

- Blood culture utilization, stratified by:
    - Mean number of blood cultures per tested patient
    - Testing prevalence (proportion of tested patients over total admissions)
- Community-onset (prior to hospital day 4) vs. Hospital-onset (on or after hospital day 4) test utilization
- Patient location, some examples
    - Adult Critical care units
    - Pediatric Critical Care units
    - Burn Critical Care
    - Trauma Critical Care
    - Specialty Care Areas (inpatient dialysis, solid organ transplant adult/pediatric)
    - Step-down units
    - Select Adult Wards
    - Oncology Wards
        - Oncology Stem Cell Transplant Wards
    - Pediatric Wards & Nurseries
        - All Other Wards
- Facility Bed Size
- Medical School Affiliation
- Facility type

Predicted Neonatal Intensive Care Unit (NICU) HOB Events

The following are a list of variables to be analyzed in risk adjustment in the NICU setting based on prior experience with CLABSI risk adjustment, but may not be comprehensive:

- Blood culture utilization, stratified by:
    - Mean number of blood cultures per tested patient
    - Testing prevalence (proportion of tested patients over total admissions)
    - Community-onset vs. Hospital-onset test utilization
- Patient birthweight categories (proportions of total infants in each category)
    - ≤ 750 grams
    - 751-1000 grams
    - 1001-1500 grams
    - 1501-2500 grams and >2500 grams
- Patient post-natal age (proportions of total infants in each category)
    - 0-14 days
    - 18-27 days
    - 28-41 days
    - ≥42 days

[Response Ends]

sp.17. Describe the denominator exclusions.

Brief narrative description of exclusions from the target population.

[Response Begins]

Not Applicable

[Response Ends]

sp.18. Provide details needed to calculate the denominator exclusions.

All information required to identify and calculate exclusions from the denominator such as definitions, time period for data collection, specific data collection items/responses, code/value sets – Note: lists of individual codes with descriptors that exceed 1 page should be provided in an Excel or csv file in required format at sp.11.

[Response Begins]

Not Applicable

[Response Ends]

sp.19. Provide all information required to stratify the measure results, if necessary.

Include the stratification variables, definitions, specific data collection items/responses, code/value sets, and the risk-model covariates and coefficients for the clinically-adjusted version of the measure when appropriate. Note: lists of individual codes with descriptors that exceed 1 page should be provided in an Excel or csv file in required format in the Data Dictionary field.

[Response Begins]

Patient location, specifically location within a Neonatal Intensive Care Unit vs. other unit, will be required to stratify the measure Standardized Infection Ratios.

[Response Ends]

sp.20. Is this measure adjusted for socioeconomic status (SES)?

[Response Begins]

No

[Response Ends]

sp.21. Select the risk adjustment type.

Select type. Provide specifications for risk stratification and/or risk models in the Scientific Acceptability section.

[Response Begins]

Statistical risk model

[Response Ends]

sp.22. Select the most relevant type of score.

Attachment: If available, please provide a sample report.

[Response Begins]

Ratio

[Response Ends]

sp.23. Select the appropriate interpretation of the measure score.

Classifies interpretation of score according to whether better quality or resource use is associated with a higher score, a lower score, a score falling within a defined interval, or a passing score

[Response Begins]

Better quality = Lower score

[Response Ends]

sp.24. Diagram or describe the calculation of the measure score as an ordered sequence of steps.

Identify the target population; exclusions; cases meeting the target process, condition, event, or outcome; time period of data, aggregating data; risk adjustment; etc.

[Response Begins]

Figure 1: Hospital-Onset Bacteremia & Fungemia Measure Diagram.

[Response Ends]

sp.27. If measure testing is based on a sample, provide instructions for obtaining the sample and guidance on minimum sample size.

Examples of samples used for testing:

• Testing may be conducted on a sample of the accountable entities (e.g., hospital, physician). The analytic unit specified for the particular measure (e.g., physician, hospital, home health agency) determines the sampling strategy for scientific acceptability testing.

• The sample should represent the variety of entities whose performance will be measured. The 2010 Measure Testing Task Force recognized that the samples used for reliability and validity testing often have limited generalizability because measured entities volunteer to participate. Ideally, however, all types of entities whose performance will be measured should be included in reliability and validity testing.

• The sample should include adequate numbers of units of measurement and adequate numbers of patients to answer the specific reliability or validity question with the chosen statistical method.

• When possible, units of measurement and patients within units should be randomly selected.

[Response Begins]

Not Applicable

[Response Ends]

sp.30. Select only the data sources for which the measure is specified.

[Response Begins]

Claims

Electronic Health Records

[Response Ends]

sp.31. Identify the specific data source or data collection instrument.

For example, provide the name of the database, clinical registry, collection instrument, etc., and describe how data are collected.

[Response Begins]

No data collection instrument.

[Response Ends]

sp.32. Provide the data collection instrument.

[Response Begins]

No data collection instrument provided

[Response Ends]

Measure testing must demonstrate adequate reliability and validity in order to be recommended for endorsement. Testing may be conducted for data elements and/or the computed measure score. Testing information and results should be entered in the appropriate fields in the Scientific Acceptability sections of the Measure Submission Form.

- 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.
- All required sections must be completed.
- For composites with outcome and resource use measures, Questions 2b.23-2b.37 (Risk Adjustment) also must be completed.

- If specified for multiple data sources/sets of specifications (e.g., claims and EHRs), Questions 2b.11-2b.13 also must be completed.
- An appendix for supplemental materials may be submitted (see Question 1 in the Additional section), but there is no guarantee it will be reviewed.
- Contact NQF staff with any questions. Check for resources at the Submitting Standards webpage.
- 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 the 2021 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.

2a. Reliability testing 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 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 evidence and are of sufficient frequency to warrant inclusion in the specifications of the measure;

AND

If patient preference (e.g., informed decision-making) 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).

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 and has demonstrated adequate discrimination and calibration
- 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 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 non-responders) 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)

Definitions

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).

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.

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.

Patient preference is not a clinical exception to eligibility and can be influenced by provider interventions.

Risk factors that influence outcomes should not be specified as exclusions.

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.

Please separate added or updated information from the most recent measure evaluation within each question response in the Scientific Acceptability sections. For example:

Current Submission:

Updated testing information here.

Previous (Year) Submission:

Testing from the previous submission here.

2a.01. Select only the data sources for which the measure is tested.

[Response Begins]

Electronic Health Records

[Response Ends]

2a.02. 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).

[Response Begins]

Not an existing dataset.

[Response Ends]

2a.03. Provide the dates of the data used in testing.

Use the following format: "MM-DD-YYYY - MM-DD-YYYY"

[Response Begins]

10-01-2015 – 12-31-2019

[Response Ends]

2a.04. Select the levels of analysis for which the measure is tested.

Testing must be provided for all the levels specified and intended for measure implementation, e.g., individual clinician, hospital, health plan.

Please refrain from selecting the following answer option(s). We are in the process of phasing out these answer options and request that you instead select one of the other answer options as they apply to your measure.

Please do not select:

- *Clinician: Clinician*
- *Population: Population*

[Response Begins]

Facility

[Response Ends]

2a.05. List the measured entities 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.

[Response Begins]

Reliability testing was performed using a random sample of the 130+ U.S. Veterans Affairs hospitals using a block randomization process to ensure geographic representation across the 5 Veterans Affairs districts (North Atlantic, Southeast, Midwest, Continental, and Pacific). Sampling was also limited to hospitals with more than 30 acute care beds. This resulted in a sample of 9 hospitals where a total of 200 charts were reviewed for reliability testing.

[Response Ends]

2a.06. Identify the number and descriptive characteristics of patients included in the analysis (e.g., age, sex, race, diagnosis), separated by level of analysis and data source; if a sample was used, describe how patients were selected for inclusion in the sample.

If there is a minimum case count used for testing, that minimum must be reflected in the specifications.

[Response Begins]

A sample was used for this analysis. To perform a validation that would assess the diagnostic accuracy overall and its stability over time and between facilities, we used data between October 1, 2015 and December 31, 2019 to avoid pre-ICD-10-CM implementation issues. We selected 9 facilities using block randomization by VA 2017 districts (North Atlantic, Southeast, Midwest, Continental, and Pacific) and above and below the median of number of operating acute care beds. We restricted the analysis to facilities with more than 30 acute care beds. Among eligible patients, we reviewed 140 randomly selected patient charts with blood cultures in the hospital onset period for HOB (including repeat review).

Table 3: Population Characteristics of Hospital-onset Bloodstream infection Sample for Validity Testing

Characteristic	Sample	-	Total Patients with Eligible Blood Culture	-
-	n	%	n	%
Total Patients	140	-	7748	-
Culture Characteristics	-	-	-	-
Mean number of unique organisms per blood culture	1.69		1.76	-
Blood cultures with growth of a yeast	11	8%	155	2%
Hospitalization Characteristics	-	-	-	-
Mean Hospital Length of Stay (Interquartile Range)	14 (9-22)	-	15 (10-22)	-
Patient Characteristics	-	-	-	-
Mean Patient Age	68.3	-	67.7	-
Female gender	4	3%		3%
Patient Race	-	-	-	-
White	106	76%	5346	69%
Black	27	19%	1860	24%
American Indian or Alaskan Native	1	1%	77	1%
Asian or Pacific Islander	1	1%	77	1%
Patient Comorbidities within the prior calendar year*	-	-	-	-
Myocardial infarction	10	7%	930	12%
Congestive heart failure	52	37%	2789	36%
Peripheral vascular disease	21	7%	1550	20%
Cardiovascular disease	24	17%	1550	20%
Dementia	13	9%	852	11%
Chronic pulmonary disease	64	46%	3022	39%
Rheumatologic disease	4	3%	155	2%
Peptic ulcer disease	7	7%	388	5%
Mild liver disease	24	17%	1317	17%

Characteristic	Sample	-	Total Patients with Eligible Blood Culture	-
Diabetes with neurologic complications	41	29%	2402	31%
Diabetes	35	7%	1550	20%
Spinal cord injury	6	4%	387	5%
Renal disease	76	54%	3642	47%
Cancer	46	33%	2557	33%
Moderate to severe liver disease	17	12%	697	9%
Metastatic cancer	15	11%	697	9%
HIV/AIDS	1	1%	77	1%
* by ICD-10-CM within the year prior	-	-	-	-

Table 3 describes characteristics, both totals and percentages, of the sample population sample and total patients with eligible cultures. Refer to the preceding text for more details.

- denotes a cell left intentionally blank

[Response Ends]

2a.07. 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.

[Response Begins]

Reliability, Data Element Validity - Reliability and data element validity testing was performed using a random sample of the 130+ U.S. Veterans Affairs hospitals using a block randomization process to ensure geographic representation across the 5 Veterans Affairs districts (North Atlantic, Southeast, Midwest, Continental, and Pacific). Sampling was also limited to hospitals with more than 30 acute care beds. This resulted in a sample of 9 hospitals from which HOB cases could be extracted. This data source was optimal for this purpose due to access to full patient records including free text of provider notes.

Face Validity- Face validity was evaluated in a cross-sectional survey of 150 hospital epidemiologists and infection preventionist members of the Society for Healthcare Epidemiology of America (SHEA) Research Network. The results of this survey have been published in the peer-reviewed literature and are covered in detail in section 2b.[6]

Risk Adjustment- Data used in the risk adjustment analysis was obtained from the Becton Dickinson Insights and Research Database (Becton, Dickinson and Company, Franklin Lakes, NJ). This included analysis of 9,202,650 admissions of adult patients 18 years or older admitted from 267 acute care hospitals. This data source had the largest number of hospitals with a breath of hospital size and specialization that best approximates the distribution The results of this study have been published in the peer-review literature.[3]

Exclusions- Exclusions are being evaluated in a study of 12 hospitals affiliated with 6 CDC Prevention Epicenters, with manual chart review of 1473 HOB events.

References:

[3] Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. *Infection Control & Hospital Epidemiology,* 1-9. doi:10.1017/ice.2022.211

[6] *Dantes et al. Hospital epidemiologists' and infection preventionists' opinions regarding hospital-onset bacteremia and fungemia as a potential healthcare-associated infection metric. Infect Control Hosp Epidemiol. 2019 May ; 40(5): 536–540. doi:10.1017/ice.2019.40.*

[Response Ends]

2a.08. List 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.

[Response Begins]

Societal risk factors were not available for analysis.

[Response Ends]

Note: If accuracy/correctness (validity) of data elements was empirically tested, separate reliability testing of data elements is not required – in 2a.09 check patient or encounter-level data; in 2a.010 enter "see validity testing section of data elements"; and enter "N/A" for 2a.11 and 2a.12.

2a.09. Select the level of reliability testing conducted.

Choose one or both levels.

[Response Begins]

Patient or Encounter-Level (e.g., inter-abstractor reliability; data element reliability must address ALL critical data elements)

[Response Ends]

2a.10. For each level of reliability testing checked above, 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.

[Response Begins]

Inter-rater reliability of chart review for hospital-onset bacteremia: For critical data elements, we used inter-abstractor (rater) reliability to determine level of agreement across 4 chart reviewers considered content experts in infectious disease and hospital epidemiology.

Data analysis included:

- Percent agreement
- Cohen's Kappa statistic to adjust for chance agreement for categorical data assessed pairwise between reviewers (10 charts) as well as against an adjudicated reference standard.

[Response Ends]

2a.11. For each level of reliability testing checked above, what were the statistical results from reliability testing?

For example, provide the percent agreement and kappa for the critical data elements, or distribution of reliability statistics from a signal-to-noise analysis. For score-level reliability testing, when using a signal-to-noise analysis, more than just one overall statistic should be reported (i.e., to demonstrate variation in reliability across providers). If a particular method yields only one statistic, this should be explained. In addition, reporting of results stratified by sample size is preferred (pg. 18, NQF Measure Evaluation Criteria).

[Response Begins]

Table 4: Reliability of among pairwise reviewers based on the number of charts reviewed.

--	**Reviewer 1**				**Reviewer 2**				**Reviewer 3**			
--	N	Agreement	Kappa	p	N	Agreement	Kappa	p	N	Agreement	Kappa	p
Reviewer 2	11	90.9%	0.79	0.004	--	--	--	--	--	--	--	
Reviewer 3	--	--	--	--	11	81.8%	0.54	0.036	--	--	--	--
Reviewer 4	11	81.8%	0.65	0.011	--	--	--	--	11	100%	1	0.001

Table 4 displays the pairwise reliability, including the numbers of cases, agreement percentage, Kappa, and p value, of HOB events among four different reviewers.

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[Response Ends]

2a.12. Interpret the results, in terms of how they demonstrate reliability.

(In other words, what do the results mean and what are the norms for the test conducted?)

[Response Begins]

Agreement and inter-rater reliability were high, especially in comparison with the literature of related healthcare associated infections (such as central line-associated bloodstream infections, where agreement among infection preventionists found kappa = 0.562 +/- 0.080).[7]

Reference:

[7] *Single-center study of interrater agreement in the identification of central line–associated bloodstream infection, American Journal of Infection Control, Volume 42, Issue 6, 2014, Pages 638-642, ISSN 0196-6553*

[Response Ends]

2b.01. Select the level of validity testing that was conducted.

[Response Begins]

Patient or Encounter-Level (data element validity must address ALL critical data elements)

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)

[Response Ends]

2b.02. 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.

[Response Begins]

Patient or Encounter-Level Validity

A.) Measure Data Element Validity

To perform a validation that would assess the diagnostic accuracy overall and its stability over time and between facilities, we used data between October 1, 2015 and December 31, 2019 to avoid pre-ICD-10-CM implementation issues. We selected 9 facilities using block randomization by VA 2017 districts (North Atlantic, Southeast, Midwest, Continental, and Pacific) and above and below the median of number of operating acute care beds. We restricted the analysis to facilities with more than 30 acute care beds. We reviewed ~200 charts each for HOB (including repeat reviews), split amongst 4 reviewers. Two reviewers were infectious diseases trained clinicians (one fellow and one attending) and two were infectious diseases epidemiologists. All had experience and training reviewing charts previously and were trained to use the standardized data collection form designed for the study. To assess inter-rater reliability, each reviewed approximately 50 charts per syndrome with approximately 20 overlapping with other reviewers (10 each with 2 other reviewers). All acute care admissions where the first positive blood culture was greater than 3 days after admission were eligible for review selection.

The reference standard for HOB was determined by chart review. The purposes of chart review were to 1) verify that the electronic extraction of criteria was correct and 2) assess whether an infection was present and whether that infection was hospital-onset. To adhere as closely as we could to NHSN definitions of HOB, the criteria used to assess admissions with candidate positive blood cultures were derived from NHSN definitions.

In addition to algorithmic criteria, other elements were extracted, such as discharge antimicrobials. Any disagreement within the chart amongst treating clinicians or between reviewers' determination of infection or hospital-onset flagged the chart for adjudication, which went to an infectious disease physician. The adjudicator annotated similarly to the original reviewers using the same criteria and did not have access to the primary reviewer's annotations.

When comparing against the reference standard, diagnostic accuracy statistics were used. Cohen's kappa was used to assess inter-rater reliability where reviewers overlapped with each other. It was also used to assess their individual performance against the adjudicated standard.

B.) Risk Adjustment Data Element Validity:

For data elements used in the risk adjustment process the following validity testing was applied:

Routine Data Quality Assurance

Data used in the risk adjustment analysis was obtained from the Becton Dickinson (BD) Infection Surveillance Software platform BD HealthSight powered by Medmined, a commercial platform where robust data validity checks ensure that data collected from electronic health record systems are performed accurately. The variables used for risk adjustment are obtained or directly calculated from Admission/Discharge/Transfer (ADT) systems, microbiology, and pharmacy or medication administration databases. These are the same sources of data used for calculation of the primary measure data elements, and the processes to assure no data is missing is described in section 2b.08.

In the BD platform, ADT, Microbiology, and pharmacy data are used for near real time alerting and reporting of healthcare-associated infections. During enrollment, each hospital engages in a months long bidirectional communication between the hospital/healthcare systems' Information Technology (IT) department, Infection Prevention department, Pharmacy department, and the BD platform IT staff and clinical subject matter experts. The hospital is only able to begin use of the product and transmission of data when all data feeds have been validated as completely accurate.

The resulting validated data collected by BD has been used in multiple publications, including the more recent publications listed here:

a. Yu, K., Gupta, V., Kabler, H., Watts, J., & Amiche, A. (2022). A multicenter analysis of inpatient antibiotic use during the 2015–2019 influenza seasons in the United States: Untapped opportunities for antimicrobial stewardship. Antimicrobial Stewardship & Healthcare Epidemiology, 2(1), E140. doi:10.1017/ash.2022.265

b. Dunne, M.W., Aronin, S.I., Yu, K.C. et al. A multicenter analysis of trends in resistance in urinary Enterobacterales isolates from ambulatory patients in the United States: 2011–2020. BMC Infect Dis 22, 194 (2022). https://doi.org/10.1186/s12879-022-07167-y

c. Vikas Gupta, Kalvin C Yu, Heidi Kabler, Janet A Watts, Amine Amiche, Antibiotic Resistance Patterns and Association With the Influenza Season in the United States: A Multicenter Evaluation Reveals Surprising Associations Between Influenza Season and Resistance in Gram-Negative Pathogens, Open Forum Infectious Diseases, Volume 9, Issue 3, March 2022, ofac039, https://doi.org/10.1093/ofid/ofac039

d. Keith S Kaye, Vikas Gupta, Aruni Mulgirigama, Ashish V Joshi, Nicole E Scangarella-Oman, Kalvin Yu, Gang Ye, Fanny S Mitrani-Gold, Antimicrobial Resistance Trends in Urine Escherichia coli Isolates From Adult and Adolescent Females in the United States From 2011 to 2019: Rising ESBL Strains and Impact on Patient Management, Clinical Infectious Diseases, Volume 73, Issue 11, 1 December 2021, Pages 1992–1999, https://doi.org/10.1093/cid/ciab560

e. The impact of infections on reimbursement in 92 US hospitals, 2015-2018, AJIC, Published:April 20, 2021DOI: https://doi.org/10.1016/j.ajic.2021.04.007

f. Finelli L, Gupta V, Petigara T, Yu K, Bauer KA, Puzniak LA. Mortality Among US Patients Hospitalized With SARS-CoV-2 Infection in 2020. JAMA Netw Open. 2021;4(4):e216556. doi:10.1001/jamanetworkopen.2021.6556

g. CDC 2019 Antibiotic Threats Report page 136. https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf

Additional Risk Adjustment Data Element Validation

An additional multi-step process was applied to ensure that the data was clinically viable and consistent with the findings of other independent peer-reviewed studies or outside data sources.

Hospital characteristics (teaching/non, tertiary, med school affiliation, etc) and number of hospital beds from ADT data was cross-referenced with AHD.com to ensure alignment and accuracy.

For multiple sites sharing a single CMS identifier, data was cross referenced with AHD.com or similar publicly available data sets to check and validate patient movement data: in this process 2 hospitals were excluded(a psychiatry hospital and a radiation oncology center) as they were did not meet the definition criteria of acute care or critical access sites (these were also flagged for review due to what appeared to be clinically implausible event rates for acute care or critical access hospitals).

Next, Hospitalization Length of Stay (LOS) was evaluated in the cohort to ensure clinical plausibility: 99% of admission had LOS < 25 days; no admissions had LOS=0 and 0.002% of all admissions had a LOS>365 days.

Regarding antimicrobial use completeness, a median of 56% of the total admissions received at least one antimicrobial, which was consistent with other broad geographic sampling studies showing approximately 50% of hospitalized patients receive antimcirobials.[8]

Systematic assessment of face validity of performance measure score as an indicator of quality or resource use

Face validity was evaluated in a cross-sectional survey of hospital epidemiologists and infection preventionist members of the Society for Healthcare Epidemiology of America (SHEA) Research Network, which demonstrated both data element validity and moderate performance score validity.[8]

The survey participants represent the healthcare professionals that would be charged with monitoring and reducing HOB rates, in addition to other healthcare-associated infections. The SHEA Research Network is a consortium of over 100 unique healthcare facilities that collaborate on multi-center research projects in this field of healthcare epidemiology, and thus represent expert users in this field.

The web-based survey was sent to 133 hospitals, with 89 responses (67% response rate).

Regarding data element validity:

Nearly all respondents stated that the required elements for an HOB measure could be extracted electronically from a hospital database, including the date of blood culture (75 of 77, 97%), the causative organism (73 of 77, 95%), and the location or unit where the culture was collected (69 of 77, 90%). Of 77 respondents, 22 (29%) stated that their hospital already measures HOB, and 12 of 77 (22%) already use HOB to guide performance improvement efforts. [8]

Regarding performance score validity:

Among 76 respondents, 41 (54%) indicated that HOB reflects quality of care provided at a hospital, 14 of 76 (18%) disagreed, 21 of 76 (28%) neither agreed nor disagreed. Opinions differed regarding the possible reaction of frontline healthcare providers to use of HOB if used as an outcome measure. Moreover, 41 of 76 (46%) anticipated that it would be well received, 23 of 76 (30%) anticipated that it would not be well received, and 18 of 76 (23%) anticipated a neutral reception. There were no statistically significant differences in these results when the data were stratified by academic affiliation, hospital size, or US versus non-US hospitals.[7]

Regarding public reporting, 27 of 77 (35%) would like HOB to be used in addition to CLABSI, 26 (34%) would prefer CLABSI alone, 17 of 77 (22%) would favor HOB over CLABSI reporting, and 7 (9%) replied "other," with most free-text responses stating that more studies were needed to decide. There were no statistically significant differences in these results when the data were stratified by academic affiliation, hospital size, or US versus non-US hospitals.[7]

References

[8] *Magill SS, Edwards JR, Beldavs ZG, Dumyati G, Janelle SJ, Kainer MA, Lynfield R, Nadle J, Neuhauser MM, Ray SM, Richards K, Rodriguez R, Thompson DL, Fridkin SK; Emerging Infections Program Healthcare-Associated Infections and Antimicrobial Use Prevalence Survey Team. Prevalence of antimicrobial use in US acute care hospitals, May-September 2011. JAMA. 2014 Oct 8;312(14):1438-46. doi: 10.1001/jama.2014.12923. PMID: 25291579.*

[7] *Dantes et al. Hospital epidemiologists' and infection preventionists' opinions regarding hospital-onset bacteremia and fungemia as a potential healthcare-associated infection metric. Infect Control Hosp Epidemiol. 2019 May ; 40(5): 536–540. doi:10.1017/ice.2019.40.*

[Response Ends]

2b.03. Provide the statistical results from validity testing.

Examples may include correlations or t-test results.

[Response Begins]

Measure Validity Testing

The sensitivity and specificity of the algorithmically determined HOB event were 95.8% (95% Confidence Interval [CI] 88.3%-99.1%) and 82.6% (95% CI 71.6%-90.7%), respectively, when compared to the manual chart-abstracted bloodstream infection standard.

Risk Adjustment Data Element Validity

The robust processes described in 2b.02 ensure that data elements used in risk adjustment were valid and without missing data.

[Response Ends]

2b.04. Provide 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?)

[Response Begins]

The diagnostic performance was high for the algorithm and chart review showed that high proportions of anticipated characteristics were observed in algorithm-positive cases.

[Response Ends]

2b.05. 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 in Importance to Measure and Report: Gap in Care/Disparities.

[Response Begins]

Measure performance was evaluated in a retrospective, ecological study based on electronic microbiological, medication and administrative data from adult patients 18 years or older admitted from October 1, 2015, through February 28, 2020 to one of 267 acute care hospitals within the Becton Dickinson Insights and Research Database (Becton, Dickinson and Company, Franklin Lakes, NJ).

The data, analysis, and interpretation for several of the following questions are taken directly verbatim from a manuscript by Yu et al[3]:

Step 1. HOB rates were calculated as the number of HOB events per 100 admissions for quarterly aggregated data. Bivariate analysis using general linear models was performed to explore the correlation between HOB rate and the candidate risk factors, which included:

Clinical measures: COB prevalence (the rate of COB events per 100 admissions); percent of intensive care unit (ICU) admissions (per all admissions); average length of hospital stay (LOS) among hospitalized patients (days of hospitalization per admission); Blood culture prevalence and intensity. Testing intensity was defined as the number of total blood cultures obtained in either the community-onset [CO] period (defined as the first 2 days of hospitalization) or the hospital-onset (HO) period (defined as day 3 or after of admission) divided by the number of total aggregate admissions that had any blood culture performed. Conceptually, testing intensity reflects the cumulative blood cultures collected among admissions with any blood culture. Testing prevalence was defined as the number of admissions with any blood culture performed in the period (CO or HO) divided by the total number of aggregate admissions and conceptually reflects the overall proportion of admissions with blood culture testing

Patient demographics: number of female patients per 100 admissions; percent of patients in each age group (18-40, 41-64, 65-80, and > 80 years old).

Facility characteristics: bed size; medical school/non-medical school affiliation; urban/rural status.

Step 2a. To evaluate HOB rates with regression models, we used negative binomial regression methods to account for : of data. The final "Complex" model used variables easily accrued from EHRs and/or reportable to the NHSN. Candidate variables considered in the Model included facility and hospital-level demographics of patients, and clinical practices of blood culture testing divided into CO or HO blood culture testing intensity and prevalence. To create the most parsimonious model, all continuous variables were partitioned into quartiles in the final "Complex" model.

Step 2b. The models calculated the predicted number of HOB events. The Standardized Infection Ratio (SIR) and confidence interval were calculated as: reported number of HOB events divided by the predicted number of HOB events. The SIR is not calculated when the predicted value is less than 1.0. Using the mid-p exact test, the calculated SIR and its confidence interval were compared to an SIR of 1.

Reference:

[3] *Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. Infection Control & Hospital Epidemiology, 1-9. doi:10.1017/ice.2022.211*

[Response Ends]

2b.06. Describe the statistical results from testing the ability to identify statistically significant and/or clinically/practically meaningful differences in performance measure scores across measured entities.

Examples may include 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.

[Response Begins]

This study demonstrated that our risk adjustment approach results in changes in the rankings of hospitals by HOB performance and can meaningfully differentiate hospital performance.

From *Yu et al* [3]:

Step 1. Our study compared rankings of the hospitals with the highest ("worst performing"/4th quartile) observed HOB rates (hospitals 1-51). Risk adjustment after applying the final "Complex Model"-derived standardized Infection Ratio (SIR) resulted in changes to the hospital rankings to unique and different degrees compared to observed HOB ranking (Figure 3).

Step 2a. We demonstrated potential real-world application of risk adjustment by quantifying changes in rank of the top 25 percentile hospitals for raw, unadjusted HOB event rates compared with Complex Model SIR ranking. Of the top 51 hospitals with the highest observed HOB rate (4th quartile), only 24 (47%) stayed in the 4th quartile ranking category, while the other 27 hospitals (52%) moved to lower rank quartiles following risk-adjustment from the Complex Model. Twelve hospitals shifted to the 2nd quartile and one hospital moved to the lowest quartile. (Figure 3)

Figure 3. Ranking change of hospitals with the highest unadjusted HOB event rates (4th quartile in ranked HOB rate) based on Complex Model-adjusted SIR.

Step 2b. A meaningful difference in the SIR was defined as an SIR and a confidence interval that was statistically different from 1. Out of 250 total facilities reporting in 2019, SIRs were able to be calculated for 205 of them. Below is a table showing the percentage of SIRs that were significantly different from 1.

Table 5. Distribution of SIRs Calculated for Hospitals Reporting in 2019.		
SIR	No. of Facilities	Percent
Not Significantly different from 1	167	81.46
Significantly lower than 1	16	7.80
Significantly higher than 1	22	10.73

Table 5 describes the number of facilities and percentage of facilities and resulting standardized infection ratios. Please see above text for additional information.

Reference:

[3] *Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. Infection Control & Hospital Epidemiology, 1-9. doi:10.1017/ice.2022.211*

[Response Ends]

2b.07. Provide 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.

In other words, what do the results mean in terms of statistical and meaningful differences?

[Response Begins]

We were able to demonstrate that the incorporation of robust data in modeling expected hospital-level HOB events leads to meaningful and practical changes in the ranking of facilities against each other in an adjusted HOB Standardized Infection Ratio Measure.

The SIR enables detection of statistically significant and clinically meaningful differences in HOB that warrant further analysis and possible action. Although exposure volume is low, leading to few statistically significant SIRs in this population, the value of the calculated SIRs can reflect practical measures of performance.

[Response Ends]

2b.08. Describe the method of testing conducted to identify the extent and distribution of missing data (or non-response) and demonstrate that performance results are not biased due to systematic missing data (or differences between responders and non-responders). Include how the specified handling of missing data minimizes bias.

Describe the steps—do not just name a method; what statistical analysis was used.

[Response Begins]

The following data quality steps were required for the Becton Dickinson Analysis to ensure there is no missing data that would bias these analysis:

Data Completeness: Becton Dickinson (BD) requires a minimum qualification of at least 3 months uninterrupted continuous data from participating hospitals of:

1. ADT (admission , discharge, transfer) feed;
2. Laboratory data inclusive but not limited to microbiology data from an uninterrupted LIS (laboratory information system) data feed, and
3. Medication order/stop feed

These are the bare minimum data requirements; if a hospital did not meet qualifications they were excluded from the study. Hospitals could contribute different time points to the total admissions data depending on the reason for interrupted data feeds. As an example, a hospital that initiated an electronic medical record vendor upgrade (or new vendor go live) that resulted in an interruption of any of the 3 key data feeds would be removed from the data set during the feed interruption time; however, once the data feed interruption resolved AND met our volume signal criteria, could then be included back into the aggregate admissions data. Therefore, as an example, hospital "X" could contribute data from July 2018 – July 2019 , go live with a new version of their EMR August 2019 which resulted in interrupted/incomplete data feed of laboratory information system until October 2019. Once all required data feeds were back up, they could resume contribution to the aggregate admissions (i.e. August 2019 and September 2019 are NOT included in the data set, but July 2018- July 2019, and October 2019 and onward ARE included).

2 gatekeeper criteria for validating 'completeness of data feed'

1) Historical Volume: BD has used its infection surveillance platform for more than 15 years that curates the data on the front end for infection prevention and antimicrobial stewardship efforts. As such, normal steady state volume of, as an example, the number of Staphylococcus aureus signals obtained from laboratory information system is quantified and deviations from that volume are flagged for further quality assurance checks on both BD side and hospital side.

2) Customer Initiated: Data feed interruptions are also identified by customer hospital during system upgrades or other instances. Given this is a retrospective data set, the consequences of such interruptions are flagged on the customer side ie lack of real time reporting of reportable hospital acquired infections or clinical alerts that use all 3 required data feeds. In this manner, then, there are 2 feedback loops that gives BD visibility to these data feed deficit events: 1) internal guardrails based upon historic steady state volume of microbiology, ADT and medication

orders data; and 2) customer hospital initiated warning on same. Often times, BD is the one that notices the disruption first.

Data Interruption Analysis

In the study, we extracted monthly aggregated hospital-level data from the BD database. Across all the 267 study hospitals, average of about 2% out of the total data feed months of 10,532 were interrupted. Prior to analysis, we examined the distribution of study variables pre- vs after interruption of data feed months and we found they were statistically the same for a specific hospital affected.

Among the study variables, there was no missing data on facility characteristics such as bed size, urban/rural status. There was no missing data in the study cohort for clinical factors such as community-onset bacteremia events and culture testing data.

Gender and Age: About 0.12% (out of the 9,202,650 admissions) had missing values on gender status. Admissions with missing gender information were excluded from analysis and we treated such cases as "missing at random" and didn't affect study event rates for this large sample study.

Intensive Care Unit (ICU): There are 1.3% missing (unreported or unable to determine) data on ICU admission status in our HOB study cohort (out of 20,310 admissions); the vast majority of the cases were associated with small hospitals with < 100 beds. Since ICU admission was deemed to be an influencing factor of the study outcomes (HOB rate or HOCDI rate), we decided to keep these cases in study cohorts and created an individual category named "unknown/unreported". The effect of such cases was assessed in our modeling analysis in addition to evaluating the ICU effect on outcomes.

Including or excluding the 'unreported ICU' in analysis did not change the statistical significance (p value) of the other variables and affected the estimated effects (coefficients) of other variables very slightly.

[Response Ends]

2b.09. Provide the overall frequency of missing data, the distribution of missing data across providers, and the results from testing related to missing data.

For example, provide results of sensitivity analysis of the effect of various rules for missing data/non-response. If no empirical sensitivity analysis was conducted, identify the approaches for handling missing data that were considered and benefits and drawbacks of each).

[Response Begins]

As described in 2b.08:

The following data quality steps were required for the Becton Dickinson Analysis to ensure there is no missing data that would bias these analysis:

Data Completeness: Becton Dickinson (BD) requires a minimum qualification of at least 3 months uninterrupted continuous data from participating hospitals of:

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hospital "X" could contribute data from July 2018 – July 2019 , go live with a new version of their EMR August 2019 which resulted in interrupted/incomplete data feed of laboratory information system until October 2019. Once all required data feeds were back up, they could resume contribution to the aggregate admissions (i.e. August 2019 and September 2019 are NOT included in the data set, but July 2018- July 2019, and October 2019 and onward ARE included).

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1) Historical Volume: BD has used its infection surveillance platform for more than 15 years that curates the data on the front end for infection prevention and antimicrobial stewardship efforts. As such, normal steady state volume of, as an example, the number of Staphylococcus aureus signals obtained from laboratory information system is quantified and deviations from that volume are flagged for further quality assurance checks on both BD side and hospital side.

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Including or excluding the 'unreported ICU' in analysis did not change the statistical significance (p value) of the other variables and affected the estimated effects (coefficients) of other variables very slightly.

[Response Ends]

2b.10. Provide 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 non-responders), and how the specified handling of missing data minimizes bias.

In other words, 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 was conducted, justify the selected approach for missing data.

[Response Begins]

As described in 2b.08:

The following data quality steps were required for the Becton Dickinson Analysis to ensure there is no missing data that would bias these analysis:

Data Completeness: Becton Dickinson (BD) requires a minimum qualification of at least 3 months uninterrupted continuous data from participating hospitals of:

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outcomes (HOB rate or HOCDI rate), we decided to keep these cases in study cohorts and created an individual category named "unknown/unreported". The effect of such cases was assessed in our modeling analysis in addition to evaluating the ICU effect on outcomes.

Including or excluding the 'unreported ICU' in analysis did not change the statistical significance (p value) of the other variables and affected the estimated effects (coefficients) of other variables very slightly.

[Response Ends]

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 eCQMs). 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.

2b.11. Indicate whether there is more than one set of specifications for this measure.

[Response Begins]

No, there is only one set of specifications for this measure

[Response Ends]

2b.12. 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. Indicate what statistical analysis was used.

[Response Begins]

[Response Ends]

2b.13. Provide the statistical results from testing comparability of performance scores for the same entities when using different data sources/specifications.

Examples may include correlation, and/or rank order.

[Response Begins]

[Response Ends]

2b.14. Provide your interpretation of the results in terms of the differences in performance measure scores for the same entities across the different data sources/specifications.

In other words, what do the results mean and what are the norms for the test conducted.

[Response Begins]

[Response Ends]

2b.15. Indicate whether the measure uses exclusions.

[Response Begins]

N/A or no exclusions

[Response Ends]

2b.16. Describe the method of testing exclusions and what was tested.

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?

[Response Begins]

A priority for CDC's NHSN with the HOB measure is to create data that is actionable for guiding infection prevention practice. Thus, we will be excluding HOB events from the HOB measure (Standardized Infection Ratio, or Observed to Expected Ratio) that are consistently not likely to be preventable.

Preliminary, unpublished data has demonstrated that HOB events among patients with chemotherapy induced pancytopenia (ICD-10 code D61.810) were highly likely to be non-preventable. HOB preventability was determined using a methodology of double subject-matter expert review with a standardized rating guide that has been previously described in the literature.[9]

Because HOB is a new measure, we anticipate that the list of HOB measure exclusions will evolve over time as users gain experience with prospective use of the measure on a large scale. We will continue to evaluate the results of high-quality studies to adjust the measure appropriately and update the HOB measure to include or exclude populations from the HOB measure with reliably low preventability.

Reference:

[9]Schrank, G., Sick-Samuels, A., Bleasdale, S., Jacob, J., Dantes, R., Gokhale, R., . . . Leekha, S. (2022). Development and evaluation of a structured guide to assess the preventability of hospital-onset bacteremia and fungemia. Infection Control & Hospital Epidemiology, 1-7. doi:10.1017/ice.2021.528

[Response Ends]

2b.17. Provide 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.

[Response Begins]

Our collaborators are conducting a study to evaluate sources and potential preventability of HOB cases at 12 hospitals affiliated with 6 CDC Prevention Epicenters from January 1, 2016-June 30, 2019, using retrospective chart review. In this study, infectious disease physicians determined the source of HOB, and rated preventability from 1-6 (1=definitely preventable to 6=definitely not preventable) using a previously validated guide.[9]

In preliminary analysis of 1473 HOB events, 167 (11%) patients had chemotherapy induced pancytopenia. Among these events, 155 (93%) were identified as non-preventable (Table 6).

Table 6: Preliminary Results of Preventability of Hospital-onset Bacteremia & Fungemia Events among Patients with and without Chemotherapy-induced Panyctopenia (ICD-10 code D61.810), among patients in 12 hospitals from January 1, 2016-June 30, 2019.

Chemotherapy-Induced Panyctopenia	Preventability		Total
-	Preventable or More Likely Preventable (Likert score 4-6)	Not Preventable or More Likely Not Preventable (Likert score 1-3)	-
No	608	698	1306
-	47%	53%	-
Yes	12	155	167
-	7%	93%	-
Total	620	853	1473

Table 6 describes preliminary results of preventability ratings for Hospital-onset Bacteremia & Fungemia Events among 1473 patients based on the presence of chemotherapy-induced pancytopenia. See text above for additional details.

-cell left intentionally blank

Reference:

[9]*Schrank, G., Sick-Samuels, A., Bleasdale, S., Jacob, J., Dantes, R., Gokhale, R., . . . Leekha, S. (2022). Development and evaluation of a structured guide to assess the preventability of hospital-onset bacteremia and fungemia. Infection Control & Hospital Epidemiology, 1-7. doi:10.1017/ice.2021.528*

[Response Ends]

2b.18. Provide your interpretation of the results, in terms of demonstrating that exclusions are needed to prevent unfair distortion of performance results.

In other words, 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.

[Response Begins]

Exclusion of patients with non-preventable HOB events from the measure will improve the face validity of the HOB measure by increasing the likelihood that remaining HOB events in the measure are preventable and resulting from gaps in the quality of hospital care.

[Response Ends]

2b.19. Check all methods used to address risk factors.

[Response Begins]

Statistical risk model with risk factors (specify number of risk factors)

[Statistical risk model with risk factors (specify number of risk factors) Please Explain]

From *Yu* et al.[3]:

Methods:

Our collaborators conducted a retrospective, ecological study based on electronic microbiological, medication and administrative data from adult patients 18 years or older admitted from October 1, 2015, through February 28,

2020 to one of 267 acute care hospitals within the BD Insights and Research Database (Becton, Dickinson and Company, Franklin Lakes, NJ) which contains electronically captured laboratory results, pharmacy orders, patient demographics, administrative data, and admission, discharge, and transfer (ADT) data feeds.[3,10-12] The distribution of hospitals in the database is similar to that of the US as a whole[3], suggesting appropriate demographic coverage.

We approached the statistical analysis in 3 steps: (1) Identify the candidate variables that influence HOB rates using bivariate analysis; (2) Construct "Complex Model" for risk-adjusting HOB using SIRs derived from regression models and assess best model fit; and (3) Compare hospital rankings using the raw unadjusted HOB rates versus using risk adjustment from the Complex Model.

Step 1. HOB rates were calculated as the number of HOB events per 100 admissions for quarterly aggregated data. Bivariate analysis using general linear models was performed to explore the correlation between HOB rate and the candidate variables, which included:

Clinical measures: Community-Onset Bacteremia (COB) prevalence (the rate of COB events per 100 admissions); percent of intensive care unit (ICU) admissions (per all admissions); average length of hospital stay (LOS) among hospitalized patients (days of hospitalization per admission); Blood culture prevalence and intensity (see definitions above).

Patient demographics: number of female patients per 100 admissions; percent of patients in each age group (18-40, 41-64, 65-80, and > 80 years old).

Facility characteristics: bed size; medical school/non-medical school affiliation; urban/rural status.

Step 2. To evaluate HOB rates with regression models, we used negative binomial regression methods to account for overdispersion of data. The "Complex Model" included hospital-level variables easily accrued from EHRs and/or already reportable to the NHSN, such as facility and hospital-level demographics of patients, and also added clinical practices of blood culture testing divided into Community-Onset or Hospital-Onset blood culture testing intensity and prevalence. To create the most parsimonious model, all continuous variables were partitioned into quartiles in the Complex Model.

We assessed higher model fit using Akaike's Information Criteria (AIC) and Bayesian Information Criteria (BIC) based on the full data in the study cohort (3,498 quarters of aggregated data associated with 9,202,650 admissions). In addition, we used cross-validation methods in variable selection and confirmed that the full-data model and the validation model had the same best set of variables in the final models.

Step 3. We compared hospital rankings based on the unadjusted (observed) HOB rate compared with rankings based on the SIRs from the Complex Model. Agreement test gamma statistic, Spearman correlation, and confidence intervals were reported. We used the calculated 1-year SIR data (2019) as an example for comparison rankings. Finally, we compared the ranking of the 4th quartile of unadjusted HOB rate hospitals to their subsequent ranking using adjusted Complex Model SIR.

All analyses were conducted using the Statistical Analysis System V9.4 (SAS Institute, Cary, NC, USA).

Results

The study included 9,202,650 patient admissions that were associated with 18,747 HOB events from 267 acute care hospitals in the US. Medical school-affiliated hospitals accounted for 38.6% of hospitals and urban facilities for 61.1%. Among study hospitals, 33.7% had <100 beds, 42.3% had 100-300 beds, and 24.0.1% had >300 beds.

Variables associated with HOB: Complex Model

Predictors associated with higher HOB in the Complex Model: increased % COB; 4th quartile LOS; larger bed size; 4th quartile % ICU admission; percent of patients aged 41-64 years; increased HO blood culture testing intensity, and increased HO blood culture prevalence (all P < 0.001). Variables negatively associated with HOB event rates were percent of patients >80 years and increased CO blood culture testing intensity. The most influential factors for HOB were HO testing intensity, COB rate, HO blood culture prevalence, hospital bed size, and CO testing intensity (negative correlation). In the Complex Model the variable of urban (vs rural) did not remain significant and was therefore not included in the final Complex Model (see Table 7). Medical school affiliation was not significant in the model.

Table 7. HOB Predictors in the Complex Model[a] with Estimated Incidence Rate Ratio

Parameter	Regression Coefficient (in logarithm scale)	Standard Error	IRR (95% CI)	P
Intercept	-3.115	0.073	-	<.0001
COB rate per 100 admissions	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	0.221	0.032	1.25 (1.17-1.33)	<.0001
3rd quartile	0.366	0.033	1.44 (1.35-1.54)	<.0001
4th quartile	0.416	0.038	1.52 (1.41-1.63)	<.0001
HO test intensity	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	0.455	0.057	1.58* (1.41-1.76)	<.0001
3rd quartile	0.658	0.059	1.93 (1.72-2.16)	<.0001
4th quartile	0.869	0.061	2.39 (2.12-2.69)	<.0001
CO test intensity	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	-0.188	0.027	0.83 (0.79-0.87)	<.0001
3rd quartile	-0.271	0.032	0.76 (0.72-0.81)	<.0001
4th quartile	-0.295	0.032	0.74 (0.70-0.79)	<.0001
HO test prevalence	-	-	-	-
< 2nd quartile	-	-	-	reference
3rd quartile	0.222	0.031	1.25 (1.18-1.33)	<.0001
4th quartile	0.327	0.034	1.39 (1.30-1.48)	<.0001
%ICU admissions	-	-	-	-
≤ 3rd quartile	-	-	-	reference
4th quartile	0.100	0.025	1.11 (1.05-1.16)	<.0001
Not reported	0.474	0.042	1.61 (1.48-1.74)	<.0001
Mean LOS	-	-	-	-
≤ 3rd quartile	-	-	-	reference
4th quartile	0.140	0.026	1.15 (1.09-1.21)	<.0001
Bed size	-	-	-	-
01-100	-	-	-	reference
101-200	0.225	0.055	1.25 (1.12-1.39)	<.0001
201-300	0.396	0.055	1.49 (1.34-1.65)	<.0001
301-500	0.358	0.054	1.43 (1.29-1.59)	<.0001
500+	0.351	0.057	1.42 (1.27-1.59)	<.0001
% of patients aged 41-64 years	-	-	-	-
1st quartile	-	-	-	reference

Parameter	Regression Coefficient (in logarithm scale)	Standard Error	IRR (95% CI)	P
2nd quartile	0.111	0.035	1.12 (1.04-1.20)	0.0015
3rd quartile	0.141	0.036	1.15 (1.07-1.24)	<.0001
4th quartile	0.325	0.038	1.38 (1.28-1.49)	<.0001
% of patients aged >80 years	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	-0.175	0.029	0.84 (0.79-0.89)	<.0001
3rd quartile	-0.234	0.033	0.79 (0.74-0.84)	<.0001
4th quartile	-0.183	0.038	0.83 (0.77-0.90)	<.0001

Table 7 describes regression coefficients, standard errors, and incidence rate ratios for HOB predictors in the Complex Model. See above text for additional details.

Abbreviations: -cell left intentionally blank, CO, community-onset; COB, community-onset bacteremia; HO, hospital-onset; HOB, hospital-onset bacteremia; ICU, intensive care unit; LOS, length of stay; IRR, incidence rate ratio (Example*= compared to those hospitals in the first quarter of HO testing intensity, hospitals in the second quarter were 1.58 times higher in HOB rate per 100 admissions.)

[a]Goodness-of-fit statistics: Akaike's Information Criteria = 12,882, Bayesian Information Criteria = 13,042.

Comparison of hospital rankings

We demonstrated potential real-world application of risk adjustment by quantifying changes in rank of the top 25 percentile hospitals for raw HOB event rates compared with Complex Model SIR ranking. Of the top 51 hospitals with the highest observed HOB rate (4th quartile), only 24 (47%) stayed in the 4th quartile ranking category, while the other 27 hospitals (52%) moved to lower rank quartiles following risk-adjustment from the Complex Model. Twelve hospitals shifted to the 2nd quartile and one hospital moved to the lowest quartile. (Figure 4)

Figure 4. Ranking change of hospitals with the highest unadjusted HOB event rates (4th quartile in ranked HOB rate) based on Complex Model-adjusted SIR. A more granular breakdown of these hospitals and the rank adjustment after applying Simple and Complex SIR is included in Supplemental Figure S2.

Conclusions

The risk adjustment achieved with the Complex Model is distinct and uniquely distinguishes differential HOB ranking when compared with unadjusted rates. In addition to incorporating factors often used in current NHSN risk adjustment models, the Complex Model includes differences in blood culture testing practices which in aggregate improve model fit, may achieve lower estimation error, and may more accurately reflect fluctuating patient case mixes at risk for HOB than some broad facility-level categories. More specifically, facility descriptors, patient characteristics, COB prevalence, and different aspects of blood culture testing intensity and prevalence during the HO and CO period were significant factors associated with HOB incidence. We are planning to include these characteristics in our NHSN HOB risk adjustment models.

References

[3] *Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. Infection Control & Hospital Epidemiology, 1-9. doi:10.1017/ice.2022.211*

[10] *McCann E, Srinivasan A, DeRyke CA, et al. Carbapenem-nonsusceptible Gram-negative pathogens in ICU and non-ICU settings in US hospitals in 2017: a multicenter study. Open Forum Infect Dis 2018;5:ofy241. doi: 10.1093/ofid/ofy241.*

[11] *Kaye KS, Gupta V, Mulgirigama A, Joshi AV, et al. Antimicrobial resistance trends in urine Escherichia coli isolates from adult and adolescent females in the United States from 2011-2019: rising ESBL strains and impact on patient management. Clin Infect Dis 2021;73:1992-1999. doi: 10.1093/cid/ciab560.*

[12] *Antibiotic resistance threats in the United States, 2019. Centers for Disease Control and Prevention website. www.cdc.gov/DrugResistance/Biggest-Threats.html. Published 2019. Accessed September 16, 2021.*

[Response Ends]

2b.20. If using statistical risk models, provide detailed risk model specifications, including the risk model method, risk factors, risk factor data sources, coefficients, equations, codes with descriptors, and definitions.

[Response Begins]

As described in 2b.19, from *Yu* et al.[3]:

Methods:

Our collaborators conducted a retrospective, ecological study based on electronic microbiological, medication and administrative data from adult patients 18 years or older admitted from October 1, 2015, through February 28, 2020 to one of 267 acute care hospitals within the BD Insights and Research Database (Becton, Dickinson and Company, Franklin Lakes, NJ) which contains electronically captured laboratory results, pharmacy orders, patient demographics, administrative data, and admission, discharge, and transfer (ADT) data feeds.[3,10-12] The distribution of hospitals in the database is similar to that of the US as a whole[3], suggesting appropriate demographic coverage.

We approached the statistical analysis in 3 steps: (1) Identify the candidate variables that influence HOB rates using bivariate analysis; (2) Construct "Complex Model" for risk-adjusting HOB using SIRs derived from regression models and assess best model fit; and (3) Compare hospital rankings using the raw unadjusted HOB rates versus using risk adjustment from the Complex Model.

Step 1. HOB rates were calculated as the number of HOB events per 100 admissions for quarterly aggregated data. Bivariate analysis using general linear models was performed to explore the correlation between HOB rate and the candidate variables, which included:

Clinical measures: Community-Onset Bacteremia (COB) prevalence (the rate of COB events per 100 admissions); percent of intensive care unit (ICU) admissions (per all admissions); average length of hospital stay (LOS) among hospitalized patients (days of hospitalization per admission); Blood culture prevalence and intensity (see definitions above).

Patient demographics: number of female patients per 100 admissions; percent of patients in each age group (18-40, 41-64, 65-80, and > 80 years old).

Facility characteristics: bed size; medical school/non-medical school affiliation; urban/rural status.

Step 2. To evaluate HOB rates with regression models, we used negative binomial regression methods to account for overdispersion of data. The "Complex Model" included hospital-level variables easily accrued from EHRs and/or already reportable to the NHSN, such as facility and hospital-level demographics of patients, and also added clinical practices of blood culture testing divided into Community-Onset or Hospital-Onset blood culture testing intensity and prevalence. To create the most parsimonious model, all continuous variables were partitioned into quartiles in the Complex Model.

We assessed higher model fit using Akaike's Information Criteria (AIC) and Bayesian Information Criteria (BIC) based on the full data in the study cohort (3,498 quarters of aggregated data associated with 9,202,650 admissions). In addition, we used cross-validation methods in variable selection and confirmed that the full-data model and the validation model had the same best set of variables in the final models.

Step 3. We compared hospital rankings based on the unadjusted (observed) HOB rate compared with rankings based on the SIRs from the Complex Model. Agreement test gamma statistic, Spearman correlation, and confidence intervals were reported. We used the calculated 1-year SIR data (2019) as an example for comparison rankings. Finally, we compared the ranking of the 4th quartile of unadjusted HOB rate hospitals to their subsequent ranking using adjusted Complex Model SIR.

All analyses were conducted using the Statistical Analysis System V9.4 (SAS Institute, Cary, NC, USA).

Results

The study included 9,202,650 patient admissions that were associated with 18,747 HOB events from 267 acute care hospitals in the US. Medical school-affiliated hospitals accounted for 38.6% of hospitals and urban facilities for 61.1%. Among study hospitals, 33.7% had <100 beds, 42.3% had 100-300 beds, and 24.0.1% had >300 beds.

Variables associated with HOB: Complex Model

Predictors associated with higher HOB in the Complex Model: increased % COB; 4th quartile LOS; larger bed size; 4th quartile % ICU admission; percent of patients aged 41-64 years; increased HO blood culture testing intensity, and increased HO blood culture prevalence (all P < 0.001). Variables negatively associated with HOB event rates were percent of patients >80 years and increased CO blood culture testing intensity. The most influential factors for HOB were HO testing intensity, COB rate, HO blood culture prevalence, hospital bed size, and CO testing intensity (negative correlation). In the Complex Model the variable of urban (vs rural) did not remain significant and was therefore not included in the final Complex Model (see Table 7). Medical school affiliation was not significant in the model.

Table 7. HOB Predictors in the Complex Model[a] with Estimated Incidence Rate Ratio

Parameter	Regression Coefficient (in logarithm scale)	Standard Error	IRR (95% CI)	P
Intercept	-3.115	0.073	-	<.0001
COB rate per 100 admissions	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	0.221	0.032	1.25 (1.17-1.33)	<.0001
3rd quartile	0.366	0.033	1.44 (1.35-1.54)	<.0001
4th quartile	0.416	0.038	1.52 (1.41-1.63)	<.0001
HO test intensity	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	0.455	0.057	1.58* (1.41-1.76)	<.0001
3rd quartile	0.658	0.059	1.93 (1.72-2.16)	<.0001
4th quartile	0.869	0.061	2.39 (2.12-2.69)	<.0001
CO test intensity	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	-0.188	0.027	0.83 (0.79-0.87)	<.0001
3rd quartile	-0.271	0.032	0.76 (0.72-0.81)	<.0001
4th quartile	-0.295	0.032	0.74 (0.70-0.79)	<.0001
HO test prevalence	-	-	-	-
< 2nd quartile	-	-	-	reference
3rd quartile	0.222	0.031	1.25 (1.18-1.33)	<.0001
4th quartile	0.327	0.034	1.39 (1.30-1.48)	<.0001
%ICU admissions	-	-	-	-
≤ 3rd quartile	-	-	-	reference
4th quartile	0.100	0.025	1.11 (1.05-1.16)	<.0001
Not reported	0.474	0.042	1.61 (1.48-1.74)	<.0001
Mean LOS	-	-	-	-
≤ 3rd quartile	-	-	-	reference
4th quartile	0.140	0.026	1.15 (1.09-1.21)	<.0001
Bed size	-	-	-	-
01-100	-	-	-	reference

Parameter	Regression Coefficient (in logarithm scale)	Standard Error	IRR (95% CI)	P
101-200	0.225	0.055	1.25 (1.12-1.39)	<.0001
201-300	0.396	0.055	1.49 (1.34-1.65)	<.0001
301-500	0.358	0.054	1.43 (1.29-1.59)	<.0001
500+	0.351	0.057	1.42 (1.27-1.59)	<.0001
% of patients aged 41-64 years	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	0.111	0.035	1.12 (1.04-1.20)	0.0015
3rd quartile	0.141	0.036	1.15 (1.07-1.24)	<.0001
4th quartile	0.325	0.038	1.38 (1.28-1.49)	<.0001
% of patients aged >80 years	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	-0.175	0.029	0.84 (0.79-0.89)	<.0001
3rd quartile	-0.234	0.033	0.79 (0.74-0.84)	<.0001
4th quartile	-0.183	0.038	0.83 (0.77-0.90)	<.0001

Table 7 describes regression coefficients, standard errors, and incidence rate ratios for HOB predictors in the Complex Model. See above text for additional details.

Abbreviations: -cell left intentionally blank, CO, community-onset; COB, community-onset bacteremia; HO, hospital-onset; HOB, hospital-onset bacteremia; ICU, intensive care unit; LOS, length of stay; IRR, incidence rate ratio (Example*= compared to those hospitals in the first quarter of HO testing intensity, hospitals in the second quarter were 1.58 times higher in HOB rate per 100 admissions.)

[a]Goodness-of-fit statistics: Akaike's Information Criteria = 12,882, Bayesian Information Criteria = 13,042.

Comparison of hospital rankings

We demonstrated potential real-world application of risk adjustment by quantifying changes in rank of the top 25 percentile hospitals for raw HOB event rates compared with Complex Model SIR ranking. Of the top 51 hospitals with the highest observed HOB rate (4th quartile), only 24 (47%) stayed in the 4th quartile ranking category, while the other 27 hospitals (52%) moved to lower rank quartiles following risk-adjustment from the Complex Model. Twelve hospitals shifted to the 2nd quartile and one hospital moved to the lowest quartile. (Figure 4)

Figure 4. Ranking change of hospitals with the highest unadjusted HOB event rates (4th quartile in ranked HOB rate) based on Complex Model-adjusted SIR. A more granular breakdown of these hospitals and the rank adjustment after applying Simple and Complex SIR is included in Supplemental Figure S2.

Conclusions

The risk adjustment achieved with the Complex Model is distinct and uniquely distinguishes differential HOB ranking when compared with unadjusted rates. In addition to incorporating factors often used in current NHSN risk adjustment models, the Complex Model includes differences in blood culture testing practices which in aggregate improve model fit, may achieve lower estimation error, and may more accurately reflect fluctuating patient case mixes at risk for HOB than some broad facility-level categories. More specifically, facility descriptors, patient characteristics, COB prevalence, and different aspects of blood culture testing intensity and prevalence during the HO and CO period were significant factors associated with HOB incidence. We are planning to include these characteristics in our NHSN HOB risk adjustment models.

References

[3] *Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. Infection Control & Hospital Epidemiology, 1-9. doi:10.1017/ice.2022.211*

[10] *McCann E, Srinivasan A, DeRyke CA, et al. Carbapenem-nonsusceptible Gram-negative pathogens in ICU and non-ICU settings in US hospitals in 2017: a multicenter study. Open Forum Infect Dis 2018;5:ofy241. doi: 10.1093/ofid/ofy241.*

[11] *Kaye KS, Gupta V, Mulgirigama A, Joshi AV, et al. Antimicrobial resistance trends in urine Escherichia coli isolates from adult and adolescent females in the United States from 2011-2019: rising ESBL strains and impact on patient management. Clin Infect Dis 2021;73:1992-1999. doi: 10.1093/cid/ciab560.*

[12] *Antibiotic resistance threats in the United States, 2019. Centers for Disease Control and Prevention website. www.cdc.gov/DrugResistance/Biggest-Threats.html. Published 2019. Accessed September 16, 2021.*

[Response Ends]

2b.21. If an outcome or resource use measure is not risk-adjusted or stratified, provide rationale and analyses to demonstrate that controlling for differences in patient characteristics (i.e., case mix) is not needed to achieve fair comparisons across measured entities.

[Response Begins]

[Response Ends]

2b.22. Select all applicable resources and methods used to develop the conceptual model of how social risk impacts this outcome.

[Response Begins]

Other (specify)

[Other (specify) Please Explain]

The broad role of social risk factors such as race, ethnicity, and social determinants of health in reporting of healthcare-associated infection metrics is not currently understood. This is currently an area of exploration for the CDC's National Healthcare Safety Network.

[Response Ends]

2b.23. Describe the conceptual and statistical methods and criteria used to test and select patient-level risk factors (e.g., clinical factors, social risk factors) used in the statistical risk model or for stratification by risk.

Please be sure to address the following: potential factors identified in the literature and/or expert panel; regression analysis; statistical significance of p<0.10 or other statistical tests; correlation of x or higher. Patient factors should be present at the start of care, if applicable. Also discuss any "ordering" of risk factor inclusion; note whether social risk factors are added after all clinical factors. Discuss any considerations regarding data sources (e.g., availability, specificity).

[Response Begins]

See 2b.19 for discussion of patient-level risk factors included in the risk adjustment model.

The broad role of social risk factors such as race, ethnicity, and social determinants of health in reporting of healthcare-associated infection metrics is not currently understood. This is currently an area of exploration for the CDC's National Healthcare Safety Network.

[Response Ends]

2b.24. Detail the statistical results of the analyses used to test and select risk factors for inclusion in or exclusion from the risk model/stratification.

[Response Begins]

As described in 2b.19, from *Yu* et al.[3]:

Methods:

Our collaborators conducted a retrospective, ecological study based on electronic microbiological, medication and administrative data from adult patients 18 years or older admitted from October 1, 2015, through February 28, 2020 to one of 267 acute care hospitals within the BD Insights and Research Database (Becton, Dickinson and Company, Franklin Lakes, NJ) which contains electronically captured laboratory results, pharmacy orders, patient demographics, administrative data, and admission, discharge, and transfer (ADT) data feeds.[3,10-12] The distribution of hospitals in the database is similar to that of the US as a whole[3], suggesting appropriate demographic coverage.

We approached the statistical analysis in 3 steps: (1) Identify the candidate variables that influence HOB rates using bivariate analysis; (2) Construct "Complex Model" for risk-adjusting HOB using SIRs derived from regression models and assess best model fit; and (3) Compare hospital rankings using the raw unadjusted HOB rates versus using risk adjustment from the Complex Model.

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Variables associated with HOB: Complex Model

Predictors associated with higher HOB in the Complex Model: increased % COB; 4th quartile LOS; larger bed size; 4th quartile % ICU admission; percent of patients aged 41-64 years; increased HO blood culture testing intensity, and increased HO blood culture prevalence (all P < 0.001). Variables negatively associated with HOB event rates were percent of patients >80 years and increased CO blood culture testing intensity. The most influential factors for HOB were HO testing intensity, COB rate, HO blood culture prevalence, hospital bed size, and CO testing intensity (negative correlation). In the Complex Model the variable of urban (vs rural) did not remain significant and was therefore not included in the final Complex Model (see Table 7). Medical school affiliation was not significant in the model.

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Parameter	Regression Coefficient (in logarithm scale)	Standard Error	IRR (95% CI)	P
% of patients aged >80 years	-	-	-	-
1st quartile	-	-	-	reference
2nd quartile	-0.175	0.029	0.84 (0.79-0.89)	<.0001
3rd quartile	-0.234	0.033	0.79 (0.74-0.84)	<.0001
4th quartile	-0.183	0.038	0.83 (0.77-0.90)	<.0001

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[a]Goodness-of-fit statistics: Akaike's Information Criteria = 12,882, Bayesian Information Criteria = 13,042.

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adjustment models, the Complex Model includes differences in blood culture testing practices which in aggregate improve model fit, may achieve lower estimation error, and may more accurately reflect fluctuating patient case mixes at risk for HOB than some broad facility-level categories. More specifically, facility descriptors, patient characteristics, COB prevalence, and different aspects of blood culture testing intensity and prevalence during the HO and CO period were significant factors associated with HOB incidence. We are planning to include these characteristics in our NHSN HOB risk adjustment models.

References

[3] *Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. Infection Control & Hospital Epidemiology, 1-9. doi:10.1017/ice.2022.211*

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[12] *Antibiotic resistance threats in the United States, 2019. Centers for Disease Control and Prevention website. www.cdc.gov/DrugResistance/Biggest-Threats.html. Published 2019. Accessed September 16, 2021.*

[Response Ends]

2b.25. Describe the analyses and interpretation resulting in the decision to select or not select social risk factors.

Examples may include prevalence of the factor across measured entities, availability of the data source, empirical association with the outcome, contribution of unique variation in the outcome, or assessment of between-unit effects and within-unit effects. Also describe the impact of adjusting for risk (or making no adjustment) on providers at high or low extremes of risk.

[Response Begins]

Social risk factors were not available in this retrospective analysis. The broad role of social risk factors such as race, ethnicity, and social determinants of health in reporting of healthcare-associated infection metrics is not currently understood. This is currently an area of exploration for the CDC's National Healthcare Safety Network.

[Response Ends]

2b.26. 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). Provide the statistical results from testing the approach to control for differences in patient characteristics (i.e., case mix) below. If stratified ONLY, enter "N/A" for questions about the statistical risk model discrimination and calibration statistics.

Validation testing should be conducted in a data set that is separate from the one used to develop the model.

[Response Begins]

From *Yu* et al.[3]:

To evaluate HOB rates with regression models, we used negative binomial regression methods to account for overdispersion of data. The "Complex Model" included hospital-level variables easily accrued from EHRs and/or already reportable to the NHSN, such as facility and hospital-level demographics of patients, and also added clinical practices of blood culture testing divided into Community-Onset or Hospital-Onset blood culture testing

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[Response Ends]

2b.27. Provide risk model discrimination statistics.

For example, provide c-statistics or R-squared values.

[Response Begins]

For questions 2b.27 through 2b.29, please refer to the following analysis that demonstrate that the Complex Model is well-specified.

Figure 5. Decile plot for HOB Complex Model.

- Figure 5 shows the extent of agreement between the observed number of HOB events and the model-predicted HOB events in each decile of predicted events.
- The diagonal line (gray dash line) represents perfect agreement between the model and observed data.
- The chart indicates that the model was well-specified.

Figure 6. A full picture of observed vs predicted HOB events based on the Complex Model.

- Figure 6 shows the extent of agreement between the observed number of HOB events and the predicted HOB events for the study data.
- The green line represents the Locally Weighted Scatterplot *Smoothing* (LOESS) of the blue circles - observed vs predicted events.
- The diagonal line (gray dash line) represents perfect agreement between the model and observed data.
- The chart indicates a very good model specification.

Numeric calibration of model fit:

- Root Mean Squared Error (RMSE) = 3.46.
- This is the standard deviation of prediction errors (residuals).
- In this modeling example, the average distance between the model-predicted numbers of HOB events and the actual HOB events was 3.46.

Other model fit statistics:

Table 8: Fit Statistics for HOB Complex Model

Fit Statistics for HOB complex model (Degree of freedom = 3,459)	
criteria	**value**
AIC	12882
BIC (smaller is better)	13042
Pearson Chi-Square	3236.98
Pearson Chi-Square/DF	0.94
Mean Squared Error	11.99

Table 8 describes fit statistics and resulting values for the HOB complex model.

[Response Ends]

2b.28. Provide the statistical risk model calibration statistics (e.g., Hosmer-Lemeshow statistic).

[Response Begins]

For questions 2b.27 through 2b.29, please refer to the following analysis that demonstrate that the Complex Model is well-specified.

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Figure 6. A full picture of observed vs predicted HOB events based on the Complex Model.

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Mean Squared Error	11.99

Table 8 describes fit statistics and resulting values for the HOB complex model.

[Response Ends]

2b.29. Provide the risk decile plots or calibration curves used in calibrating the statistical risk model.

The preferred file format is .png, but most image formats are acceptable.

[Response Begins]

For questions 2b.27 through 2b.29, please refer to the following analysis that demonstrate that the Complex Model is well-specified.

Figure 5. **Decile plot for HOB Complex Model.**

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AIC	12882
BIC (smaller is better)	13042

Fit Statistics for HOB complex model (Degree of freedom = 3,459)	
Pearson Chi-Square	3236.98
Pearson Chi-Square/DF	0.94
Mean Squared Error	11.99

Table 8 describes fit statistics and resulting values for the HOB complex model.

[Response Ends]

2b.30. Provide the results of the risk stratification analysis.

[Response Begins]

Not Applicable.

[Response Ends]

2b.31. Provide your interpretation of the results, in terms of demonstrating adequacy of controlling for differences in patient characteristics (i.e., case mix).

In other words, what do the results mean and what are the norms for the test conducted?

[Response Begins]

The risk adjustment achieved with the Complex Model is distinct and uniquely distinguishes differential HOB ranking when compared with unadjusted rates. In addition to incorporating factors often used in current NHSN risk adjustment models, the Complex Model includes differences in blood culture testing practices which in aggregate improve model fit, may achieve lower estimation error, and may more accurately reflect fluctuating patient case mixes at risk for HOB than some broad facility-level categories. More specifically, facility descriptors, patient characteristics, COB prevalence, and different aspects of blood culture testing intensity and prevalence during the HO and CO period were significant factors associated with HOB incidence. We are planning to include these characteristics in our NHSN HOB risk adjustment models.

[Response Ends]

2b.32. Describe any additional testing conducted to justify the risk adjustment approach used in specifying the measure.

Not required but would provide additional support of adequacy of the risk model, e.g., testing of risk model in another data set; sensitivity analysis for missing data; other methods that were assessed.

[Response Begins]

Not Applicable.

[Response Ends]

3. Feasibility

Extent to which the specifications including measure logic, require data that are readily available or could be captured without undue burden and can be implemented for performance measurement.

3.01. Check all methods below that are used to generate the data elements needed to compute the measure score.

[Response Begins]

Generated or collected by and used by healthcare personnel during the provision of care (e.g., blood pressure, lab value, diagnosis, depression score)

Coded by someone other than person obtaining original information (e.g., DRG, ICD-10 codes on claims)

[Response Ends]

3.02. Detail to what extent the specified data elements are available electronically in defined fields.

In other words, indicate whether data elements that are needed to compute the performance measure score are in defined, computer-readable fields.

[Response Begins]

ALL data elements are in defined fields in a combination of electronic sources

[Response Ends]

3.03. If ALL the data elements needed to compute the performance measure score are not from electronic sources, specify a credible, near-term path to electronic capture, OR provide a rationale for using data elements not from electronic sources.

[Response Begins]

Not applicable.

[Response Ends]

3.04. Describe any efforts to develop an eCQM.

[Response Begins]

This measure will not be an eCQM.

[Response Ends]

3.06. Describe difficulties (as a result of testing and/or operational use of the measure) regarding data collection, availability of data, missing data, timing and frequency of data collection, sampling, patient confidentiality, time and cost of data collection, other feasibility/implementation issues.

[Response Begins]

From a data availability standpoint, all data elements required for the calculation of the measure are available within the EHR, ADT, or electronic claims (date of admission, laboratory results, medication administration, ICD-10 codes, etc.). As this is an electronic measure, Information Technology services will need to be involved in the set-up of the data retrieval/data exchange process. However, unlike many current CDC NHSN measures, once the initial data retrieval has been set-up, the exchange can occur automatically on a monthly basis without requiring the time of an Infection Preventionist.

While PHI/PII will be collected as part of the measure to allow for patient matching across months of data, NHSN has a long history and experience with collecting and storing such data, and has extensive rules and data use agreements in place to ensure that information is only available to authorized individuals.

[Response Ends]

Consider implications for both individuals providing data (patients, service recipients, respondents) and those whose performance is being measured.

3.07. Detail any fees, licensing, or other requirements to use any aspect of the measure as specified (e.g., value/code set, risk model, programming code, algorithm),

Attach the fee schedule here, if applicable.

[Response Begins]

There are no fees or licensing requirements

[Response Ends]

4. Usability and Use

Extent to which potential audiences (e.g., consumers, purchasers, providers, policy makers) are using or could use performance results for both accountability and performance improvement to achieve the goal of high-quality, efficient healthcare for individuals or populations.

Extent to which intended audiences (e.g., consumers, purchasers, providers, policy makers) can understand the results of the measure and are likely to find them useful for decision making.

NQF-endorsed measures are expected to be used in at least one accountability application within 3 years and publicly reported within 6 years of initial endorsement, in addition to demonstrating performance improvement.

4a.01. Check all current uses. For each current use checked, please provide:

- **Name of program and sponsor**
- **URL**
- **Purpose**
- **Geographic area and number and percentage of accountable entities and patients included**
- **Level of measurement and setting**

[Response Begins]

Not in use

[Not in use Please Explain]

This is a new measure.

[Response Ends]

4a.02. Check all planned uses.

[Response Begins]

Public reporting

Public Health/Disease Surveillance

Payment Program

Quality Improvement with Benchmarking (external benchmarking to multiple organizations)

Quality Improvement (internal to the specific organization)

[Response Ends]

4a.03. If not currently publicly reported OR used in at least one other accountability application (e.g., payment program, certification, licensing), explain why the measure is not in use.

For example, do policies or actions of the developer/steward or accountable entities restrict access to performance results or block implementation?

[Response Begins]

This measure is not yet in use because it is a new measure and the NHSN application module to accept data from facilities has not yet been released to the public.

[Response Ends]

4a.04. If not currently publicly reported OR used in at least one other accountability application, provide a credible plan for implementation within the expected timeframes: used in any accountability application within 3 years, and publicly reported within 6 years of initial endorsement.

A credible plan includes the specific program, purpose, intended audience, and timeline for implementing the measure within the specified timeframes. A plan for accountability applications addresses mechanisms for data aggregation and reporting.

[Response Begins]

Reporting into the HOB NHSN module is planned to launch in early 2023, and the first year or so would emphasize recruitment of hospitals to begin reporting data which can be used to track internal quality improvement.

Once a full calendar year of baseline national data is collected, NHSN will begin to produce risk-adjusted Standardized Infection Ratios (SIR) which will be communicated back to the facilities to benchmark their HOB performance against other facilities.

CDC has a long-standing collaborative relationship with the Centers for Medicare and Medicaid (CMS), who has been kept aware of the progress of this measure and its targeted suitability for various quality programs. This measure has received endorsement for the Hospital IQR Program in the 2021 MAP Measures Under Consideration meeting conditional upon NQF endorsement (MUC2021-100).

[Response Ends]

4a.05. Describe how performance results, data, and assistance with interpretation have been provided to those being measured or other users during development or implementation.

Detail how many and which types of measured entities and/or others were included. If only a sample of measured entities were included, describe the full population and how the sample was selected.

[Response Begins]

The CDC NHSN has over a decade of experience in helping hospitals and healthcare facilities collect and benchmark various healthcare quality measures for both internal quality improvement and reporting to various incentive programs.

NHSN has an existing base of >135,000 active users representing over 38,000 healthcare facilities. The enrollment process includes some basic user education, and NHSN staff provide regular educational updates, newsletters, webinars, and online resources for users. NHSN also has an active user support desk that fielded over 90,000 tickets in 2021.

As soon as a facility reports at least a month of data into the HOB module, the data and initial analytics will be available for the facility within the NHSN application. After the first year of data collection, a national baseline will be established, which can be used by the facilities and other entities for benchmarking to drive improvement practices. Much like existing NHSN measures, the HOB module will provide monthly reports through the NHSN applications regarding HOB performance. HOB will be included in the HAI progress report that is published on an annual basis.

[Response Ends]

4a.06. Describe the process for providing measure results, including when/how often results were provided, what data were provided, what educational/explanatory efforts were made, etc.

[Response Begins]

The CDC NHSN has over a decade of experience in helping hospitals and healthcare facilities collect and benchmark various healthcare quality measures for both internal quality improvement and reporting to various incentive programs.

NHSN has an existing base of >135,000 active users representing over 38,000 healthcare facilities. The enrollment process includes some basic user education, and NHSN staff provide regular educational updates, newsletters, webinars, and online resources for users. NHSN also has an active user support desk that fielded over 90,000 tickets in 2021.

As soon as a facility reports at least a month of data into the HOB module, the data and initial analytics will be available for the facility within the NHSN application. After the first year of data collection, a national baseline will be established, which can be used by the facilities and other entities for benchmarking to drive improvement practices. Much like existing NHSN measures, the HOB module will provide monthly reports through the NHSN applications regarding HOB performance. HOB will be included in the HAI progress report that is published on an annual basis.

[Response Ends]

4a.07. Summarize the feedback on measure performance and implementation from the measured entities and others. Describe how feedback was obtained.

[Response Begins]

Facilities are not yet able to report, to no feedback is available yet from those being measured.

[Response Ends]

4a.08. Summarize the feedback obtained from those being measured.

[Response Begins]

Facilities are not yet able to report, to no feedback is available yet from those being measured.

[Response Ends]

4a.09. Summarize the feedback obtained from other users.

[Response Begins]

Facilities are not yet able to report, to no feedback is available yet from other users.

[Response Ends]

4a.10. Describe how the feedback described has been considered when developing or revising the measure specifications or implementation, including whether the measure was modified and why or why not.

[Response Begins]

The CDC NHSN measure development process has included collaboration with investigators from outside organizations, including Becton Dickinson and the Veterans Health Administration (cited earlier), who have provided analysis essential to developing this measure.

The measure development team has also been proactive about announcing the ongoing development of this measure to key stakeholders, including CMS, and stakeholder professional societies such as the Society for Healthcare Epidemiology of America.

Once the measure is released and available for reporting in NHSN in 2023, users will have the opportunity to provide scientific, technical, or other feedback through our NHSN Help Desk, which fields thousands of user inquiries each year.

[Response Ends]

4b.01. You may refer to data provided in Importance to Measure and Report: Gap in Care/Disparities, but do not repeat here. Discuss any progress on improvement (trends in performance results, number and percentage of people receiving high-quality healthcare; Geographic area and number and percentage of accountable entities and patients included). If no improvement was demonstrated, provide an explanation. If not in use for performance improvement at the time of initial endorsement, provide a credible rationale that describes how the performance results could be used to further the goal of high-quality, efficient healthcare for individuals or populations.

[Response Begins]

HOB is a new measure and not currently in widespread use for performance improvement.

HOB will provide hospitals with a benchmarked measure of healthcare-associated infections that result in bloodstream infections. Current infection control practices have focused on sub-sets of the HOB population: patients with Central line-associated bloodstream infections (CLABSI, NQF #0139) and hospital-onset methicillin-resistant *Staphylococcus aureus* (HO-MRSA, NQF #1716). These NQF endorsed measures have been instrumental in reducing these types of healthcare-associated infections, despite some setbacks related to the COVID-19 pandemic[13]. However, from the perspective of a patient who develops a bloodstream infection during their hospital stay, it may seem unusual that infection prevention efforts would only focus on subsets of these infections and not all of these infections. Thus, the HOB measure has great potential for building upon the success of the CLABSI and HO-MRSA measures by driving further reductions in a broader spectrum of HAIs.

The HOB measure has additional advantages of being calculated algorithmically and objectively without the requirement for infection preventionists to directly adjudicate each event. Therefore, it may be better suited for may quality reporting programs than some related HAI measures.

References

[13]*Weiner-Lastinger, L., Pattabiraman, V., Konnor, R., Patel, P., Wong, E., Xu, S., . . . Dudeck, M. (2022). The impact of coronavirus disease 2019 (COVID-19) on healthcare-associated infections in 2020: A summary of data reported to the National Healthcare Safety Network. Infection Control & Hospital Epidemiology, 43(1), 12-25. doi:10.1017/ice.2021.362*

[Response Ends]

4b.02. Explain any unexpected findings (positive or negative) during implementation of this measure, including unintended impacts on patients.

[Response Begins]

Not applicable as this is a new measure.

[Response Ends]

4b.03. Explain any unexpected benefits realized from implementation of this measure.

[Response Begins]

Not applicable as this is a new measure.

[Response Ends]

5. Comparison to Related or Competing Measures

If a measure meets the above criteria and there are endorsed or new related measures (either the same measure focus or the same target population) or competing measures (both the same measure focus and the same target population), the measures are compared to address harmonization and/or selection of the best measure.

If you are updating a maintenance measure submission for the first time in MIMS, please note that the previous related and competing data appearing in question 5.03 may need to be entered in to 5.01 and 5.02, if the measures are NQF endorsed. Please review and update questions 5.01, 5.02, and 5.03 accordingly.

5.01. Search and select all NQF-endorsed related measures (conceptually, either same measure focus or target population).

(Can search and select measures.)

[Response Begins]

0139: National Healthcare Safety Network (NHSN) Central line-associated Bloodstream Infection (CLABSI) Outcome Measure

1716: National Healthcare Safety Network (NHSN) Facility-wide Inpatient Hospital-onset Methicillin-resistant Staphylococcus aureus (MRSA) Bacteremia Outcome Measure

[Response Ends]

5.02. Search and select all NQF-endorsed competing measures (conceptually, the measures have both the same measure focus or target population).

(Can search and select measures.)

[Response Begins]

[Response Ends]

5.03. If there are related or competing measures to this measure, but they are not NQF-endorsed, please indicate the measure title and steward.

[Response Begins]

#1731 PC-04 Health Care-Associated Bloodstream Infections in Newborns – The Joint Commission (ENDORSEMENT REMOVED)

#0478 Neonatal Blood Stream Infection Rate (NQI 03) – Agency for Healthcare Research and Quality (ENDORSEMENT REMOVED)

[Response Ends]

5.04. If this measure conceptually addresses EITHER the same measure focus OR the same target population as NQF-endorsed measure(s), indicate whether the measure specifications are harmonized to the extent possible.

[Response Begins]

Yes

[Response Ends]

5.05. If the measure specifications are not completely harmonized, identify the differences, rationale, and impact on interpretability and data collection burden.

[Response Begins]

Not Applicable

[Response Ends]

5.06. Describe why this measure is superior to competing measures (e.g., a more valid or efficient way to measure quality). Alternatively, justify endorsing an additional measure.

Provide analyses when possible.

[Response Begins]

As stated in 4b.01:

HOB will provide hospitals with a benchmarked measure of healthcare-associated infections that result in bloodstream infections. Current infection control practices have focused on sub-sets of the HOB population: patients with Central line-associated bloodstream infections (CLABSI, NQF #0139) and hospital-onset methicillin-resistant *Staphylococcus aureus* (HO-MRSA, NQF #1716). These NQF endorsed measures have been instrumental in reducing these types of healthcare-associated infections, despite some setbacks related to the COVID-19 pandemic[13]. However, from the perspective of a patient who develops a bloodstream infection during their hospital stay, it may seem unusual that infection prevention efforts would only focus on subsets of these infections and not all of these infections. Thus, the HOB measure has great potential for building upon the success of the CLABSI and HO-MRSA measures by driving further reductions in a broader spectrum of HAIs.

The HOB measure has additional advantages of being calculated algorithmically and objectively without the requirement for infection preventionists to directly adjudicate each event. Therefore, it may be better suited for may quality reporting programs than some related HAI measures.

References

[13]*Weiner-Lastinger, L., Pattabiraman, V., Konnor, R., Patel, P., Wong, E., Xu, S., . . . Dudeck, M. (2022). The impact of coronavirus disease 2019 (COVID-19) on healthcare-associated infections in 2020: A summary of data reported to the National Healthcare Safety Network. Infection Control & Hospital Epidemiology, 43(1), 12-25. doi:10.1017/ice.2021.362*

[Response Ends]

Appendix

Supplemental materials may be provided in an appendix.:

No appendix

Contact Information

Measure Steward (Intellectual Property Owner): Centers for Disease Control and Prevention

Measure Steward Point of Contact: Dantes, Raymund, vic5@cdc.gov

Measure Developer if different from Measure Steward: Centers for Disease Control and Prevention

Measure Developer Point(s) of Contact: Dantes, Raymund, raymund.dantes@emoryhealthcare.org

Dantes, Raymund, vic5@cdc.gov

Additional Information

1. Provide any supplemental materials, if needed, as an appendix. All supplemental materials (such as data collection instrument or methodology reports) should be collated one file with a table of contents or bookmarks. If material pertains to a specific criterion, that should be indicated.

[Response Begins]

No appendix

[Response Ends]

2. List the workgroup/panel members' names and organizations.

Describe the members' role in measure development.

[Response Begins]

CDC Measure Development Team:

Raymund Dantes, MD MPH – *Medical Advisor to NHSN*. Dr. Dantes has been the primary CDC subject matter expert and scientific lead in this measure development. Dr. Dantes has coordinated background research efforts, written the measure protocols, and authored measure applications to NQF and the MUC list.

Andrea Benin, MD – *Branch Chief, Surveillance Branch, Division of Healthcare Quality Promotion, CDC*. Dr. Benin directly supervises the development, implementation, and management of NHSN. Dr. Benin has been directly involved with all aspects of this measure development.

Jonathan Edwards, M.Stat- *Statistics Team Leader, Surveillance Branch, Division of Healthcare Quality Promotion, CDC*. Mr. Edwards has overseen statistical analysis for background investigative studies and for measure development.

Kristi Betz, MD, PhD- *Validation Team Lead, Division of Healthcare Quality Promotion, CDC*. Dr. Betz has been directly involved with coordination of background research efforts and creation of measure specifications.

Denise Leaptrot, MSA, SM- *Subject Matter Expert, Protocol and Validation Team, Division of Healthcare Quality Promotion, CDC*. Ms. Leaptrot has been directly involved with the creation of measure specifications.

Measure Development and Testing Partners:

Becton, Dickinson and Company: Team lead by Kalvin Yu, MD, FIDSA. Evaluated measure performance and risk adjustment in a retrospective, ecological study using the BD Insights and Research Database (Yu, K., Ye, G., Edwards, J., Gupta, V., Benin, A., Ai, C., & Dantes, R. (2022). Hospital-onset bacteremia and fungemia: An evaluation of predictors and feasibility of benchmarking comparing two risk-adjusted models among 267 hospitals. *Infection Control & Hospital Epidemiology, 43*(10), 1317-1325. doi:10.1017/ice.2022.211.)

Veterans Health Administration: Team lead by Makoto Jones MD, MS. Evaluated several HOB candidate event definitions and provided validity testing using patient data in the US Department of Veterans Affairs Health Care System.

CDC Prevention Epicenters: A CDC-funded network of 11 academic centers of excellence and academic investigators working to implement innovative strategies to improve healthcare quality and patient safety. Provided expert review and guidance related to measure specifications. CDC leadership, coordinating, and scientific personnel include John Jernigan, MD, MS, Sujan Reddy, MD, James Baggs, PhD, and Natalie Mccarthy, MPH.

[Response Ends]

3. Indicate the year the measure was first released.

[Response Begins]

This measure is planned for release in 2023.

[Response Ends]

4. Indicate the month and year of the most recent revision.

[Response Begins]

August 2022.

[Response Ends]

5. Indicate the frequency of review, or an update schedule, for this measure.

[Response Begins]

Scheduled reviews are conducted on an annual basis.

[Response Ends]

6. Indicate the next scheduled update or review of this measure.

[Response Begins]

The next scheduled review is planned 1 year following measure release.

[Response Ends]

7. Provide a copyright statement, if applicable. Otherwise, indicate "N/A".

[Response Begins]

N/A

[Response Ends]

8. State any disclaimers, if applicable. Otherwise, indicate "N/A".

[Response Begins]

The measure specifications and supporting documentation are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

[Response Ends]

9. Provide any additional information or comments, if applicable. Otherwise, indicate "N/A".

[Response Begins]

N/A

[Response Ends]