CBE ID

3309

Title

Risk-Standardized Survival Rate for Adults with In-Hospital Cardiac Arrest.

Project

Management of Acute Events, Chronic Disease, Surgery, and Behavioral Health

Endorsement Status

Endorsed

Is Under Review

No

Next Maintenance Cycle

Fall 2029

Previous Endorsement Cycle

Fall 2024

Initial Endorsement

Mon, 06/10/2019 - 10:11

Steward

American Heart Association

1.0 New or Maintenance

Maintenance

1.1 Measure Structure

Single Measure

1.3 Electronic Clinical Quality Measure (eCQM)

No

1.6 Measure Description

This measure estimates a hospital-level risk standardized survival rate (RSSR) for adult patients aged 18 years and older who experience an in-hospital cardiac arrest.

1.7 Composite Measure

No

1.7 Measure Type

Outcome

1.8 Level of Analysis

Facility

1.9 Care Setting

Emergency Department, Hospital: Acute Care Facility, Hospital: Critical Access, Hospital: Inpatient

1.10 Measure Rationale

In-hospital cardiac arrest affects an estimated 300,000 adults annually in the United States with high morbidity and mortality. Survival rates after in-hospital cardiac arrest varies markedly across hospitals. While this may be, in part, due to differences in patient severity of illness across hospitals, it is also likely that such variation reflects hospital-level differences in resuscitation response, processes-of-care, and structures in place to treat cardiac arrest. To date, there has not been a risk-standardized survival rate measure for this population by which facilities can compare themselves to others. This measure is intended to fill that gap.

1.13 Data Dictionary

Attached

1.14 Numerator

Patients who were alive at discharge

1.14a Numerator Details

Patients who were alive at discharge

Target population for the numerator is identified via the Get with The Guidelines (GWTG) – Resuscitation Registry using the time period and data fields below:

Time Period for Data Collection: At each hospital, survival status at discharge during the measurement period.

'Discharge Status' = Alive

1.15 Denominator

Patients aged 18 years and older with pulseless in-hospital cardiac arrest who received chest compression and/or defibrillation.

1.15a Denominator Details

Patients aged 18 years and older with in-hospital cardiac arrest who received chest compression and/or defibrillation

Target population for the denominator is identified via the Get With The Guidelines (GWTG) – Resuscitation Registry using the time period and data fields below:

Time Period for Data Collection: 12 consecutive months

‘Age at System Entry’ >= 18 years

AND

‘First documented pulseless rhythm’ = Asystole, Pulseless Electrical Activity (PEA), Pulseless Ventricular Tachycardia, or Ventricular Fibrillation (VF)

AND

‘Did patient receive chest compressions and/or defibrillation during this event?’ = Yes

1.15b Denominator Exclusions

- Patients with recurrent IHCA during admission.
- Patients whose discharge status data is pending or missing.

1.15c Denominator Exclusions Details

Denominator exclusions are identified via the Get with The Guidelines (GWTG) – Resuscitation Registry using the time period and data fields below:

Time Period for Data Collection: At each hospital discharge during the measurement period.

COUNT_OF ('Event Type' = CPA) = 1[CP1]

OR

‘Discharge Status’ = Pending OR Null

1.15d Age Group

Adults (18-64 years), Older Adults (65 years and older)

1.16 Type of Score

Rate/proportion

1.17 Measure Score Interpretation

Better performance = Higher score

1.18 Calculation of Measure Score

Measure score is calculated as follows:

1. Check to see if hospitals have one or more cases of in-hospital cardiac arrest during the measurement period; exclude hospitals without at least one case of in-hospital cardiac arrest

2. Check to see if patients with in-hospital cardiac arrest are aged 18 years of age and older; exclude patients less than 18 years of age

3. Check to see if patients had first documented pulseless rhythms of Asystole, Pulseless Electrical Activity (PEA), Pulseless Ventricular Tachycardia, or Ventricular Fibrillation (VF); exclude patients without these first documented pulseless rhythms

4. Check to see if patients received chest compressions and/or defibrillation during CPA in-hospital cardiac arrest event; exclude patients who did not receive chest compressions and/or defibrillation

5. Check patient discharge status; exclude patients with a blank or pending discharge status

6. Check to see if patients had multiple in-hospital cardiac arrest events during this admission; exclude patients with recurrent in-hospital cardiac arrest events

7. Identify patients who were alive at discharge and include in numerator

8. Extract variables for inclusion in risk adjustment for patients included in the measure, The measure is adjusted using the following variables:

a. Age

b. COVID-19

c. Initial cardiac arrest rhythm

d. Hospital location

e. Hypotension

f. Sepsis

g. Metastatic or hematologic malignancy

h. Respiratory insufficiency

i. Renal insufficiency

j. Metabolic or electrolyte abnormality

k. Major trauma

l. Mechanical ventilation

m. Intravenous Vasopressor

9. Measure Calculation:

a. Create a model for predictors of in-hospital cardiac arrest (IHCA). Since patients at a given hospital with IHCA will have correlated outcomes, we will use a multivariable hierarchical logistical regression model, wherein patients are nested within hospitals in the model and hospitals are modeled as random effects.

b. Consider a number of demographic (age category, sex) and comorbidity values (includes pre-existing conditions and interventions in place at the time of cardiac arrest) for model inclusion. Essentially, we consider almost all illness severity and cardiac arrest variables as potential predictors in the model.

c. Generate an initial “full” model with significant predictors of survival to discharge.

d. Within this initial “full” model, work to sequentially eliminate predictors with the smallest contribution to the model. This is done to derive a more parsimonious or “reduced”, model with 99% of initial “full” model’s predictive ability – in essence, to create a model with many fewer variables with almost identical predictive (discriminative) ability as the “full” model. The advantage of the reduced model is to reduce the burden of data collection for the risk-standardized survival rate (RSSR) measure.

e. Assess model discrimination with the “reduced” model with c-statistics and perform model validation by comparing the R2 of the predicted and observed plots (this information is described in later sections).

f. Once the “reduced” predictive model is confirmed, as above, RSSRs for each hospital can be calculated. This can be accomplished by multiplying the weighted average unadjusted survival rate for the entire study sample by the hospital’s predictive v. expected survival rate. So, a hospital with a predicted vs. expected survival rate >1 would have an RSSR higher than the weighted mean, and one with a ratio <1 would have an RSSR below the weighted mean.

g. Determine the expected survival number (denominator) by applying the model’s regression coefficients for covariates to each patient and summing up the probabilities for all patients within that hospital. This number uses the average hospital-level random intercept in the model.

h. The predicted survival number (numerator) is the number of survivors at a hospital, which is determined in the same way as the expected survival (above) except that the hospital's specific random intercept from the model is used.

1.19 Measure Stratification Details

The measure is not stratified.

1.20 Types of Data Sources

Registries

1.25 Data Source Details

The American Heart Association Get With The Guidelines-Resuscitation registry for IHCA .

Abstractors enter data on patients with IHCA into the Get With The Guidelines-Resuscitation (GWTG-R) registry.

1.26 Minimum Sample Size

No minimum sample size.

2.1 Attach Logic Model

Logic Model 2024.pdf

2.2 Evidence of Measure Importance

Survival after IHCA can be affected by several structures and processes put in place by hospitals, such as the utilization of increased training of staff in resuscitation procedures (including the use of mock codes), earlier recognition of patients in cardiac arrest and shorter staff response time, and improved quality of chest compressions (Chan, 2015). Recent studies have shown that increased duration of resuscitation attempt, prompt administration of epinephrine, and earlier times to defibrillation can improve survival rates after an IHCA. A study utilizing data from the Get With The Guidelines-Resuscitation Registry found that while an optimum duration of resuscitation attempt could not be determined, hospitals that conducted longer resuscitations (median 25 minutes) had higher rates of return of spontaneous circulation and in-hospital survival, compared to hospitals that conducted shorter resuscitations (median 16 minutes) (Goldberger, et al., Lancet 2012). Another study found that hospitals with lower rates of delayed epinephrine treatment had higher survival rates for their patients with IHCA (Khera R, Chan PS, Donnino M, Girota S, Circulation, 2016). In a third study, while it is widely known that prompt delivery of defibrillation contributes to improved survival, the extent of benefit was unclear until a landmark study quantified that patients with delays in defibrillation treatment (>2 minutes) had half the odds of survival to hospital discharge compared with promptly treated patients (Chan PS et al, NEJM, 2008). Additionally, survival rates after IHCA have improved with facility participation in the Get With The Guidelines-Resuscitation registry (from 16% up to 24% from 2010 to 2013) which could be associated with improved resuscitation care (Chan, National Academies, 2015).

These and other studies suggest that hospital variation in survival rates for IHCA are not merely due to chance but are influenced by whether hospitals have systems and processes in place to deliver high-quality intra- and post-resuscitation care. Please see accompanying logic model for additional factors which influence site-level rates of IHCA survival.

Chan PS. Public health burden of in-hospital cardiac arrest. 2015. Available at: http://www.nationalacademies.org/hmd/~/media/Files/Report%20Files/2015/...

Chan PS, Krumholz HM, Nichol G, Nallamothu BK, and the American Heart Association National Registry of Cardiopulmonary Resuscitation Investigators. Delayed time to defibrillation after in-hospital cardiac arrest. N Engl J Med. 2008;358:9-17.

Girota S, Nallomothu BK, Spertus JA, Li Y, Krumholz HM, Chan PS for the American Heart Association Get With The Guidelines—Resusciation Investigators. Trends in survival after in-hospital cardiac arrest. N Engl J Med. 2012 November 15;367(20):1912-1920.

Goldberger ZD, Chan PS, Berg RA, Kronick, SL, Cooke CR, Lu M, Bamerjee M, Hayward RA, Krumholz HM, Nallomouthou BK, for the American Heart Association Get With The Guidelines—Resusciation (formerly the National Registry of Cardiopulmonary Resusciation) Investigators. Duration of resuscitation efforts and survival after in-hospital cardiac arrest: an observational study. Lancet. 2012;380:1473-81

Khera R, Chan PS, Donnino M, Girota S for the American Heart Association Get With The Guidelines-Resusciation Investigators. Hospital variation in time to epinephrine for nonshockable in-hospital cardiac arrest. Circulation. 2016;134:2105-2114.

2.4 Performance Gap

The updated re-derived model for RSSR for IHCA was developed in 2022. However, since we developed the updated model in 2022, there have been 2 additional years of data (2022 and 2023).

Thus, the following section on Performance (2.4) will provide mean performance statistics by decile for the period when we re-derived and re-validated the RSSR measure (March 2020 to December 2021) – Table 1 below.

In addition, to provide more years of data to illustrate performance scores by decile, we also provide a second table based on the sample of 369 hospitals with at least 5 cases of IHCA annually between July 1, 2020 and December 31, 2023 (measurement period of 3.5 years) – Table 1b attached in 2.4a. During this time period, the mean performance risk-standardized survival rate was 22.8% (Standard Deviation: 5.3%) and the median performance rate was 22.8% (IQR: 19.5%, 25.6%). The minimum performance rate was 6.1% and the maximum performance rate was 48.5%. Performance score deciles are included in Table 1b.

Note: The updated RSSR model included new variables, including COVID-19 infection for model adjustment for patient case-mix to ensure adequate capture of patients' illness severity.

Table 1. Performance Scores by Decile

Performance Gap

	Overall	Minimum	Decile_1	Decile_2	Decile_3	Decile_4	Decile_5	Decile_6	Decile_7	Decile_8	Decile_9	Decile_10	Maximum
Mean Performance Score	21.0%	6.8%	13.6%	16.7%	18.1%	19.4%	20.5%	21.5%	22.5%	23.8%	25.5%	30.6%	45.6%
N of Entities			36	37	37	37	38	37	37	37	37	38	
N of Persons / Encounters / Episodes			7053	6107	4919	5257	4113	4618	4823	5864	4529	6639	

2.4a Attach Performance Gap Results

2.4a Additional Performance Gap Results.pdf

2.6 Meaningfulness to Target Population

Unlike other PROs which measure quality of life or other process-of-care measure, the RSSR measure for in-hospital cardiac arrest focuses on patients' likelihood of survival. As a measure assessing survival, it is assumed that the target population values this outcome, given that the alternative outcome is death.

3.1 Contributions Towards Closing Care Gaps

On the template we downloaded, this section was marked as optional.

4.1 Feasibility Assessment

No feasibility issues have arisen for this measure. There is minimal missing data due to the GWTG-Resuscitation registry's submission requirements. Data for comorbidities and interventions in place at the time of cardiac arrest, demographics, and cardiac arrest variables have nearly no missing data. Importantly, the information for each of the model variables are routinely collected on patients with IHCA in hospital records.

Race, the variable with the highest missing data rate, was not included in the risk-adjustment model. We intentionally chose to not include race/ethnicity as a covariate in deriving our model for risk-standardized survival rates for IHCA so as to not mask disparities in care and outcomes for this condition by race. Including race in the model would have, in effect, made it more acceptable for hospitals with higher proportions of black patients with IHCA to have lower survival rates compared with other hospitals.

Supplemental Table 1 in the 7.1 Supplemental Attachments summarizes the study sample for re-deriving the RSSR measure. Again, the missing rate for variables is <0.1%. Given the low missing data rates, no imputation or other sensitivity analyses were performed. Given the extremely low rates of missing data, we do not believe that the observed performance is systematically biased.

4.3 Feasibility Informed Final Measure

Given that data for this measure are collected through the Get With the Guidelines – Resuscitation registry and not collected electronically via electronic health record, no feasibility assessment was performed. No issues with data collection have been identified and no modifications have been made to this measure due to issues with data collection, sampling, or cost.

4.4 Proprietary Information

Proprietary measure or components (e.g., risk model, codes), without fees

4.4a Fees, Licensing, or Other Requirements

Interested parties must enter a licensing agreement with the American Heart Association in order to use this measure in their programs.

5.1.1 Data Used for Testing

We used data from the American Heart Association's GWTG-Resuscitation registry. This is a national quality improvement registry for IHCA with several hundred participating U.S. hospitals. Participation is voluntary. Rigorous quality standards are applied to the data and both annual and ad hoc performance reports are generated for participating centers to track and improve their performance.

03-01-2020 – 12-31-2021

This time frame was chosen as we had updated the RSSR model in 2022 to include COVID-19 as a predictor variable in the model. As COVID-19 emerged in the U.S. in March of 2020, and as GWTG-Resuscitation introduced this variable in data collection at around the same time, we chose 03-01-2020 as the initial date for the dataset to derive the new RSSR measure.

5.1.2 Differences in Data

PREVIOUS SUBMISSION - Data from 2007-2010 in the GWTG-Resuscitation registry were used to derive the initial risk-standardization model (initial derivation cohort) and validate that model (initial validation cohort). We also performed prospective validation and reliability testing using data from 01/2011 to 05/2015 (prospective validation cohort). The initial derivation and validation using data from 2007-2010 comprised 48,841 patients with IHCAs. The prospective validation was performed on 61,934 patients with IHCA between January of 2011 to May of 2015.

CURRENT SUBMISSION – To re-derive the RSSR measure in the setting of the COVID-19 pandemic, we used data from 53,922 patients with IHCA from GWTG-Resuscitation between March 2020 and December 2021.

5.1.3 Characteristics of Measured Entities

There were 372 hospitals in this timeframe for re-deriving the RSSR measure.

We started with 65,323 IHCAs. We excluded:

- 9,813 recurrent IHCAs
- 785 IHCAs with missing information on survival
- 803 pediatric IHCAs

The final cohort comprised 53,922 index IHCAs in adult patients from 372 hospitals.

5.1.4 Characteristics of Units of the Eligible Population

PREVIOUS SUBMISSION

Initial Patients for Development and Validation of RSSR Measure. We initially had 2 validation cohorts for the RSSR measure. The derivation cohort used data from GWTG-Resuscitation between 2007 and 2010. Two-thirds of patients during this time period comprised the derivation cohort, and one-third of patients comprised the initial validation cohort. We then prospectively validated the RSSR measure using data from 2011 to May 2015. Supplemental Table 2 in the 7.1 Supplemental Attachments summarizes this population.

Although data from 2007-2010 in the GWTG-Resuscitation registry were used to derive the initial risk-standardization model (initial derivation cohort) and validate that model (initial validation cohort), we also performed prospective validation and reliability testing using data from 01/2011 to 05/2015 (prospective validation cohort). The initial derivation and validation using data from 2007-2010 comprised 48,841 patients with IHCAs. The prospective validation was performed on 61,934 patients with IHCA between January of 2011 to May of 2015.

CURRENT SUBMISSION.

Given the need to re-derive the RSSR measure due to the impact of COVID-19 on IHCA survival, we used data from GWTG-Resuscitation between March 2020 to December 2021 to re-derive the RSSR measure. In this analysis, 70% of patients comprised the derivation cohort and 30% of patients comprised the validation cohort. Supplemental Table 1 in the 7.1 Supplemental Attachments summarizes this population.

To re-derive the RSSR measure in the setting of the COVID-19 pandemic, we used data from 53,922 patients with IHCA from GWTG-Resuscitation between March 2020 and December 2021.

5.2.1 Level(s) of Reliability Testing Conducted

Accountable entity level (i.e., measure score) (e.g., signal-to-noise analysis)

5.2.2 Method(s) of Reliability Testing

I. Data Element (Test-Retest Reliability):

We evaluated the test-retest reliability at the level of data elements by reviewing patients with IHCA who had a second IHCA during the same hospitalization between 03/01/2020 and 12/31/2021. This approach enabled us to examine 2 independent abstractions of data for the same patient. For certain characteristics that would not change (e.g., age, sex), we would expect near perfect reproducibility. For other characteristics (e.g. hypotension at time of cardiac arrest) we would expect that any patient with hypotension during the first IHCA may not be hypotensive during the second IHCA, so many of the patient variables were felt to be dynamic. Other factors such as cardiac arrest rhythm and location of arrest are liable to change with the second cardiac arrest. We therefore focused on 4 variables in assessing reliability at the data element level: age, sex, prior history of myocardial infarction (MI), and prior history of heart failure (HF).

Assessment of test-retest reliability among 9813 patients with 2 IHCAs during the same hospitalization:

- Age: 99.98% concordance (9811 patients had same age during recurrent IHCA as index IHCA, 2 discordant ages)

- Sex: 100% concordance (all 9813 patients had the same sex during the recurrent IHCA as during the index IHCA)
- Prior history of MI: 97.50% concordance (245 patients had discordant responses during the second IHCA as compared with the index IHCA)
- Prior history of CHF: 96.72% concordance (322 patients had discordant responses during the second IHCA as compared with the index IHCA)

II. Performance Measure Score (Signal-to-Noise):

We performed signal-to-noise analyses for both the initial derivation of the RSSR measure and on the re-derivation of the RSSR measure. For the signal-to-noise analysis, we followed the methodology as outlined in a Rand Corporation technical report by John L Adams. The document is available at the following URL (https://www.rand.org/content/dam/rand/pubs/technical_reports/2009/RAND_...). This approach uses a beta-binomial model that assumes the hospital's score is a binomial random variable conditional on the hospital's true value that comes from a beta distribution. The beta distribution is a very flexible distribution on the interval from 0 to 1 and can have any distribution within the interval and can be skewed left or right or even U-shaped. It is the most common distribution for probabilities on the 0-1 interval.

PREVIOUS SUBMISSION (2011 to May 2015)

For the entire prospective validation period of 2011 to May 2015, the signal-to noise analysis resulted in a mean reliability score of 0.76 and a median reliability score was 0.78 for hospitals eligible for the measure. For the 1-year period of 2013, the mean and median reliability scores were 0.70 and 0.72, respectively. And for year 2014, the mean and median reliability scores were 0.67 and 0.68, respectively.

CURRENT SUBMISSION (03/01/2020 to 12/31/2021)

See Supplemental Table 3 in the 7.1 Supplemental Attachments where we provide mean and median reliability assessments for all sites, and hospitals in the top 3 and 2 quartiles of IHCA case volume, as well as those in the top quartile of IHCA case volume (Q4).

5.2.3 Reliability Testing Results

Please refer to 4.2.2 for both the method of testing and the statistical results.

The re-derived model for RSSR for IHCA was developed in 2022. However, as the updated model was developed in 2022, there have since been 2 additional years of IHCA data (2022 and 2023). Thus, the following section on Reliability Testing (4.2.3) will provide mean reliability statistics by decile for the period for the re-derivation and re-validation of the RSSR measure (March 2020 to December 2021) – see Table 2 below. In addition, to provide more years of data to assess reliability by decile, we also provide a second table based on the time period between July 2020 and December 2023 (measurement period of 3.5 years) – see Table 2b attached in 4.2.3a.

5.2.3a Attach Additional Reliability Testing Results

4.2.3a Additional Reliability Testing Results.pdf

5.2.4 Interpretation of Reliability Results

Assessment of test-retest reliability among patients with recurrent IHCA during 03/01/2020 to 12/31/2021:

We found no major misclassification (e.g., >5%) by test-retest reliability for any assessable risk factor that is not dynamic (i.e., not likely to change between procedures). The reliability testing at the patient level provides strong support for the test-retest reliability of the variables in the GWTG-Resuscitation registry.

Signal to Noise Analysis:

The signal to noise ratio analysis measures the confidence levels in differentiating performance between hospitals. These reliability results for the RSSR measure demonstrate variability that is attributable to real differences in hospital quality as opposed to measurement error.

In the signal-to-noise analyses for the Maintenance of Measure submission (where we have re-derived the RSSR measure for the period of March 2020 to December 2021), the median signal-to-noise ratio was 0.788 when all hospitals were considered.

- When hospitals in the lowest quartile of IHCA volume were excluded (>Q1, or those with <29 IHCAs were excluded), the median signal-to-noise ratio improved to 0.812.

- When hospitals in the lower half were excluded (>Q2, or those with <95 IHCAs were excluded), the median signal-to-noise ratio improved to 0.867.

- And when only the highest volume quartile hospitals were considered (>Q3, or those with

< 209 IHCAs were excluded), the median signal-to-noise ratio improved to 0.905

Although the signal-to-noise results in these subsets suggest higher confidence in differentiating performance, the signal-to-noise ratio results for all hospitals suggests good discrimination as to whether variability is attributable to real differences.

Moreover, reliability testing was robust, especially from deciles 3 to 10. Reliability findings were higher (median signal-to-noise ratio of 0.829) when we assessed reliability statistics using a longer time period of July 2020 to December 2023. Collectively, we believe that the test-retest reliability data and signal to noise analysis strongly support the reliability of the data elements and resulting performance scores.

Table 2. Accountable Entity Level Reliability Testing Results by Denominator, Target Population Size

Accountable Entity-Level Reliability Testing Results

	Overall	Minimum	Decile_1	Decile_2	Decile_3	Decile_4	Decile_5	Decile_6	Decile_7	Decile_8	Decile_9	Decile_10	Maximum
Reliability	0.788		0.137	0.378	0.564	0.680	0.762	0.810	0.851	0.889	0.928	0.988	
Mean Performance Score	21.0%	6.8%	13.6%	16.7%	18.1%	19.4%	20.5%	21.5%	22.5%	23.8%	25.5%	30.6%	45.6%
N of Entities			37	37	37	37	38	37	37	37	37	38	
N of Persons / Encounters / Episodes			266	986	1838	2766	4174	5305	7340	9848	15308	6091	

5.3.1 Level(s) of Validity Testing Conducted

Accountable entity level (i.e., measure score) (e.g., criterion validity)

5.3.3 Method(s) of Validity Testing

Predictive Validity testing of the RSSR Measure

We conducted predictive validity analyses to determine whether a hospital's RSSR for the outcome of in-hospital survival to discharge would be strongly correlated with a hospital's 30-day survival rate for IHCA. Predictive validity testing at the hospital level was conducted and found that there was tight correlation between hospitals with the highest RSSR for IHCA and those with the highest 30-day risk-standardized survival rate. Leveraging a prior linkage of GWTG-Resuscitation data with Medicare data, we computed RSSR for survival to discharge and at 30-days after discharge for patients with IHCA at each hospital. We found that there was a very strong correlation between a hospital's RSSR (survival to discharge) with that same hospital's risk-standardized 30-day survival rate (weighted kappa of 0.72 [95% CI: 0.68-0.76]). (See Figure 1 attached in 4.3.4a)

Since follow-up after hospital discharge is not routinely performed for IHCA, this study was important to show that the RSSR measure for survival to discharge for hospitals was a strong predictor for that hospital's 30-day survival rate for IHCA, thus confirming that hospitals with the highest RSSR were not merely discharging patients to hospice with subsequent deaths in the immediate post-discharge period.

5.3.4 Validity Testing Results

Predictive Validity Testing – There is a very strong correlation between a hospital's RSSR (survival to discharge) with that same hospital's risk-standardized 30-day survival rate (weighted kappa of 0.72 [95% CI: 0.68-0.76]). (See Figure 1 attached in 4.3.4a)

5.3.4a Attach Additional Validity Testing Results

4.3.4a Additional Validity Testing Results.pdf

5.3.5 Interpretation of Validity Results

PREDICTIVE VALDIITY

Demonstrating that the RSSR measure, focused on survival to discharge, is highly correlated with a hospital's 30-day survival rate for IHCA suggests that this measure is valid and an important measure for hospital survival outcomes. This is particularly important since IHCA registries currently do not collect information on 30-day outcomes due to the difficulties in data collection post-discharge, unlike other cardiovascular conditions such as acute myocardial infarction, heart failure and stroke. Demonstrating that in-hospital survival with the RSSR measure is a highly predictive proxy for a hospital's 30-day survival rate for IHCA underscores the importance of the RSSR measure for IHCA.

We found significant variation in RSSR for IHCA among hospitals. As seen in Figure 2 (attached in 4.3.4a), among the 372 hospitals, the median hospital rate of survival for IHCA was 21.0%, with an inter-quartile range of 18.1% to 23.9%. For a hospital measure such as survival, some hospitals had survival rates that were >25% above the median survival rate (i.e., hospitals with RSSRs of >26.2%), whereas other hospitals had survival rates that were >25% below the median survival rate (i.e., hospitals with RSSRs of <15.8%). This wide distribution of hospital RSSRs for IHCA suggest meaningful differences in performance for the ultimate outcome of importance to patients—survival.

MEANINGFUL DIFFERENCESS IN PERFORMANCE

A meaningful difference identifies the potential for improvement in comparison to others. To place the potential benefits of this model in context, it is helpful to compare the lives that could be saved if the worst 25% of hospitals would have had the average survival of all hospitals. The average RSSR rate in the lowest quartile of hospitals was 15%. Given an average IHCA volume of 145 cases/hospital, this suggests ~445 lives would be saved per year just among these 372 hospitals in GWTG-Resuscitation alone. There would be twice as many lives saved per year (~890) if the worst performing hospitals were to achieve the RSSR of the top-quartile hospitals which had an average RSSR of 27%. If this RSSR measure applied to all U.S. hospitals, the amount of lives saved could be nearly 10-15-fold higher, as participating hospitals in GWTG-Resuscitation represent 7-8% of all U.S. hospitals.

We believe that the use of the RSSR measure for IHCA identifies high and low hospital performers for resuscitation care. As a result, the model holds great promise for improving the survival outcomes for patients with IHCA.

5.3.2 Type of Accountable Entity Level Validity Testing Conducted (derived)

Empirical validity testing at the accountable entity-level (e.g., criterion validity, construct validity, known groups analysis)

5.4.1 Methods Used to Address Risk Factors

Statistical risk adjustment model with risk factors

5.4.2 Conceptual Model Rationale

Social risk factors were not used in this risk model for the following reasons:

While proxy variables could be considered, these were not believed to be as relevant to an inpatient survival model, in contrast to a longer-term model on survival where difficulties with access to medical care, affording medications or follow-up rehabilitation would be more important considerations to a survival outcome. Moreover, while it may be true that worse social risk factors might be associated with more severe illness or patient case-mix at the time of presentation, we had direct access to detailed clinical variables describing the severity of illness at the time of IHCA and we incorporated such factors (e.g., hypotension, mechanical ventilation, renal insufficiency) into the model for risk-adjustment already, providing a much more specific means of accounting for differences in patients' risk between hospitals. Accordingly, given the rich clinical data available through the American Heart Association's GWTG-Resuscitation registry, social risk factors would not likely contribute much improvement to this particular risk model, which exhibits excellent goodness of fit.

We will note in the original submission of the RSSR measure, we had not included race in the risk model but had examined the influence of race on the RSSR measure by dividing study hospitals into quartiles of patients with IHCA who were of black race. Across hospitals, the median percentage of IHCA patients of black race was 11% (IQR: 4% to 27%). In the table below, we describe that hospitals with the lowest proportion of black patients with IHCA (quartile 1) had a higher rate of unadjusted and risk-standardized survival for cardiac arrest as compared with hospitals that had the highest proportion of black patients (quartile 4), suggesting some degree of disparity in RSSRs by a hospital's racial composition despite adjustment for patient case-mix severity (see Supplemental Table 4 in the 7.1 Supplemental Attachments).

It is important to note that in our models, we deliberately chose to not include race/ethnicity as a covariate in deriving our model for risk-standardized survival for IHCA so as to not mask disparities in care and outcomes for this condition by race. Including race in the model would have, in effect, made it more acceptable for hospitals with higher proportions of black patients with in-hospital cardiac arrest to have lower survival rates compared with other hospitals.

5.4.2a Attach Conceptual Model

4.4.2a Conceptual Model_1.pdf

5.4.3 Variable Distribution Across Measured Entities

In Supplemental Table 5 in the 7.1 Supplemental Attachments, we present a summary of patient characteristics used in the risk-adjustment model for the derivation and validation cohort to re-derive the RSSR measure for IHCA. The 13 variables in the final Reduced Model are designated with the '**#**' notation in the column to the left.

Since the RSSR measure for IHCA is a hospital-level measure, race-specific survival was not assessed at the patient-level. Instead, we examined the influence of race on the RSSR measure by dividing study hospitals into quartiles of patients with IHCA who were of black race. Across hospitals, the median percentage of IHCA patients of black race was 11% (IQR: 4% to 27%). In Supplemental Table 4, we outline that hospitals with the lowest proportion of black patients with IHCA (quartile 1) had a higher rate of unadjusted and risk-standardized survival for cardiac arrest as compared with hospitals that had the highest proportion of black patients (quartile 4), suggesting some degree of disparity in RSSRs by hospital racial composition despite adjustment for patient case-mix severity.

Otherwise, social risk factors were not used in this risk model. First, as a clinical registry used for quality assessment and improvement, detailed socioeconomic variables are not available. Second, while other proxy variables could be considered, these were not felt to be relevant to an inpatient survival outcome model, in contrast to a longer-term outcome model where issues such as difficulties with access to care and affording medications or rehabilitation care would be more important. Moreover, while it may be true that worse social risk factors might be associated with more severe illness at the time of presentation, we had direct access to detailed clinical variables describing the severity of illness and believe that incorporating such factors in our survival model (e.g., initial rhythm, sepsis, renal insufficiency) is a much more accurate means of stratifying risk. Accordingly, we believe that inclusion of social risk factors would not likely improve this model of RSSR

5.4.4 Risk/Case-Mix Adjustment Modeling and/or Stratification Results

As described above in section 1.18, the procedure to derive the RSSR is as follows:

Measure Calculation:

a. Create a model for predictors of in-hospital cardiac arrest (IHCA). Since patients at a given hospital with IHCA will have correlated outcomes, we will use a multivariable hierarchical logistical regression model, wherein patients are nested within hospitals in the model and hospitals are modeled as random effects.

b. Consider a number of demographic (age category, sex) and comorbidity values (includes pre-existing conditions and interventions in place at the time of cardiac arrest) for model inclusion. Essentially, we consider almost all illness severity and cardiac arrest variables as potential predictors in the model.

c. Generate an initial “full” model with significant predictors of survival to discharge.

d. Within this initial “full” model, work to sequentially eliminate predictors with the smallest contribution to the model. This is done to derive a more parsimonious or “reduced”, model with 99% of initial “full” model’s predictive ability – in essence, to create a model with many fewer variables with almost identical predictive (discriminative) ability as the “full” model. The advantage of the reduced model is to reduce the burden of data collection for the risk-standardized survival rate (RSSR) measure.

e. Assess model discrimination with the “reduced” model with c-statistics and perform model validation by comparing the R2 of the predicted and observed plots (this information is described in later sections).

f. Once the “reduced” predictive model is confirmed, as above, RSSRs for each hospital can be calculated. This can be accomplished by multiplying the weighted average unadjusted survival rate for the entire study sample by the hospital’s predictive v. expected survival rate. So, a hospital with a predicted vs. expected survival rate >1 would have an RSSR higher than the weighted mean, and one with a ratio <1 would have an RSSR below the weighted mean.

g. Determine the expected survival number (denominator) by applying the model’s regression coefficients for covariates to each patient and summing up the probabilities for all patients within that hospital. This number uses the average hospital-level random intercept in the model.

h. The predicted survival number (numerator) is the number of survivors at a hospital, which is determined in the same way as the expected survival (above) except that the hospital’s specific random intercept from the model is used.

5.4.5 Calibration and Discrimination

We developed the updated RSSR model in the 70% derivation data set and tested its discrimination and calibration (using both the Hosmer-Lemeshow test and the slope of the predicted vs. observed risk). We then replicated this in the 30% validation data set. Data from 03/01/2020 to 12/31/21 were used for the derivation and validation data sets.

5.4.5a Attach Calibration and Discrimination Testing Results

4.4.5a Calibration and Discrimination Testing Results.pdf

5.4.6 Interpretation of Risk/Case-mix Factor Findings

By risk-standardizing survival rates across hospitals, the model allows for comparable comparisons between hospitals for performance in IHCA. The adjustment of 13 variables which are highly predictive of IHCA survival ensures that potential differences in patient case-mix are addressed. Given the detailed information on clinical comorbidities (e.g., hypotension), conditions present prior to cardiac arrest (e.g., COVID-19 infection), interventions in place at the time of cardiac arrest (e.g., mechanical ventilation), and cardiac arrest characteristics (e.g., initially detectable cardiac arrest rhythm), adjustment for these patient factors provides a RSSR measure that reflects hospital differences in resuscitation response, processes-of-care, and systems.

Lastly, as discussed above in Section 4.4.2, social risk factors are not included in this risk-standardized outcome measure.

5.4.7 Final Approach to Address Risk Factors

Statistical risk adjustment model with risk factors

6.1.1 Current Status

In use

6.1.3 Current Use(s)

Public Reporting, Professional Certification or Recognition Program, Quality Improvement with Benchmarking (external benchmarking to multiple organizations), Quality Improvement (Internal to the specific organization)

6.1.3 Program Details

Name of the program and sponsor
Get With the Guidelines-Resusitation; American Heart Association
URL of the program
https://www.heart.org/en/professional/quality-improvement/get-with-the-guidelin…
Purpose of the program
Get With The Guidelines®-Resuscitation (GWTG-R) has its roots in the American Heart Association's National Registry of Cardiopulmonary Resuscitation (NRCPR), started in 1999 to

collect resuscitation data from hospitals nationwide and create evidence-based
Geographic area and percentage of accountable entities and patients included
Geographical locations across the United States are covered and patients experiencing an in-hospital cardiac arrest are included. GWTG-Resuscitation includes over 1 million patients across the country.
Applicable level of analysis and care setting

Data collection and feedback reporting are performed using the American Heart Association's Patient Management Tool™ (PMT), an online, interactive system provided by IQVIA. Patient level data is entered into this tool for each participating hospital in the acute care setting.

6.2.1 Actions of Measured Entities to Improve Performance

Improvement in survival after IHCA can be affected by resuscitation processes-of-care, systems in place, and structures at each hospital. This measure is part of the Get With the Guidelines-Resuscitation measure set which aims to improve IHCA outcomes. GWTG provides participating hospitals with resources to help improve their outcomes, such as the 2023 Nallamothu et al. article describing 10 Steps Toward improving IHCA, as well as the ability to monitor and compare their own performance to that of other hospitals or state/national rates.

Nallamothu BK, Greif R, Anderson T, Atiq H, Couto TB, Considine J, De Caen AR, Djärv T, Doll A, Douma MJ, Edelson DP, Xu F, Finn JC, Firestone G, Girotra S, Lauridsen KG, Leong CK, Lim SH, Morley PT, Morrison LJ, Moskowitz A, Mullasari Sankardas A, Mohamed MTM, Myburgh MC, Nadkarni VM, Neumar RW, Nolan JP, Athieno Odakha J, Olasveengen TM, Orosz J, Perkins GD, Previdi JK, Vaillancourt C, Montgomery WH, Sasson C, Chan PS; International Liaison Committee on Resuscitation. Ten Steps Toward Improving In-Hospital Cardiac Arrest Quality of Care and Outcomes. Circ Cardiovasc Qual Outcomes. 2023 Nov;16(11):e010491. doi: 10.1161/CIRCOUTCOMES.123.010491. Epub 2023 Nov 10. PMID: 37947100; PMCID: PMC10659256.

6.2.2 Feedback on Measure Performance

Any feedback on measure implementation or substance is given to internal American Heart Association teams directly from hospitals involved in the GWTG registries.

6.2.3 Consideration of Measure Feedback

GWTG measures are used for recognition awards for participating hospitals. Feedback from participating facilities ensures that our measure is being used how we envision and continuing to help hospitals improve their IHCA survival.

6.2.4 Progress on Improvement

Survival rates after in-hospital cardiac arrest had started to improve prior to the introduction of the feedback reports on hospitals' RSSR for in-hospital cardiac arrest. Nonetheless, the continued wide variation in rates of survival to discharge after IHCA among hospitals underscores the importance of this measure and the feedback of its results to facilities in order to support efforts to improve patient survival rates after IHCA. Table 1 and Table1b in Section 2.4 show greater mean performance scores when additional follow-up time is added.

6.2.5 Unexpected Findings

We did not find any unexpected findings.

7.1 Supplemental Attachment

Supplemental Tables.zip

Measure Developer POC

United States

The measure developer is different from the measure steward

No

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Steward Organization

American Heart Association

Steward Organization URL

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