Appendix A: Tabak Mortality Score (Model details)

Our heart failure mortality risk score is based on the predictive model for inpatient mortality that was developed by Tabak, Johannes, and Silber for heart failure.[1] Their original multivariable logistic regression model has been updated from 2006-2007 data in the CareFusion Research Database, CareFusion, Marlborough, MA. The update generated for this current study is reflected in the coefficients and variable scores shown in Table A. We applied the coefficients to data from our study sample to produce the risk score. We formally tested the mortality risk score on the total sample of patients including those who died in the inpatient and 30 day post-discharge period. The model revealed outstanding discrimination for mortality. The c-statistic for inpatient mortality was 0.92 (95% CI, 0.89 – 0.94) and 0.84 (95% CI, 0.82-0.86) for 30 day mortality.

Table A. Tabak Mortality Score for Heart Failure, Recalibrated using 2006-07 data (N=131,498)*

Variable	Model Coefficient†	Score Constant‡	Example score for a 55 year old patient	
			Variable value§	Variable score‖
Demographics				
Age, (each year over 45)	0.04	.4 (per year >45)	4	4
Laboratory Values				
Albumin (g/dL)				
≤ 2.4	0.82	8	0	0
2.5-2.7	0.58	6	1	6
Total bilirubin (mg/dL)				
> 1.4	0.55	5	0	0
CPK				
≤ 35 or > 300	0.29	3	0	0
Creatinine (mg/dL)				
> 2.0	0.11	1	1	1
Na (mEq/dL)				
≤ 130	0.54	5	1	5
131-135 or > 145	0.28	3	0	0
BUN (mg/dL)				
35-50	0.59	6	0	0
51-70	0.90	9	1	9
> 70	1.22	12	0	0
Arterial pCO2 (mm Hg)				
≤ 35 or > 60	0.45	5	0	0
WBC (k/mm^3)				
> 10.9	0.39	4	0	0
Troponin I > 1 ng/mL or CKMB >9 ng/mL				
Yes	0.68	7	1	7
Glucose (a)				
≤ 70	0.34	3	0	0
PT INR				
> 1.2	0.22	2	0	0
BNP<=100 or proBNP<=1000 (b)				
Yes	-0.47	-5	0	0
BNP>2400 or proBNP>18000				
Yes	0.34	3	1	3
Arterial pH				
7.26-7.33	0.57	6	0	0
> 7.49	0.12	1	0	0
≤ 7.25	0.95	9	1	9
Vital Signs				
Temperature (F)				
≤ 95 or > 100	0.39	4	1	4
Pulse (/min)				
99 - 119	0.27	3	0	0
> 119	0.34	3	1	3
Diastolic BP (mm Hg)				
54-62	0.16	2	0	0
≤ 53	0.26	3	0	0
Systolic BP (mm Hg)				
81-100	0.54	5	0	0
≤ 80	0.96	10	1	10
			Total score	**61**

* Cardinal-Health-Research-Database, Cardinal Health MediQual, Marlborough, MA.
† Equal to the estimated β coefficients derived from a multivariable logistic regression model applied to Cardinal Health data updated by 2006-2007 data.
‡ Model coefficient times 10, rounded to nearest integer (except for age)
§ Age= (55-45) x 0.4 = 4; all other variables are indicator variables.
‖ Age: variable score = variable value; all others, variable score = variable value x score constant.

Appendix B: Definitions for Readmission Factor Variables

The variables used in the mortality risk score model are listed in Appendix A. Definitions are included below for additional variables used in the study that were electronically collected from Parkland Health and Hospital System electronic medical record.

1. History of depression or anxiety. Binary variable that equals 1 if patient had at least one of the following ICD-9-CD codes documented during a Parkland inpatient admission within the 12 months prior to the index admission: 293.83, 293.84, 297.1, 297.9, 300.0, 300.00, 300.01, 300.02, 300.09, 300.11, 300.23, 300.29, 300.4, 300.9, 301.6, 301.83, 301.9, 306.1, 306.4, 308.0, 308.3, 308.9, 309.0, 309.24, 309.28, 309.29, 309.9, 311, and 312.20.
2. Living Alone. A binary variable which equals 1 if the patient reported him/herself as single, widowed, or divorced at the time of the index admission. The variable equals 0, otherwise.
3. Male. Binary variable which equals 1 if gender/sex was male. The variable equals 0, otherwise.
4. Black. Binary variable which equals 1 if race was classified as black; the variable equals 0, otherwise.
5. Hispanic. Binary variable which equals 1 if patient reported as having Hispanic heritage. The variable equals 0, otherwise.
6. Age. Number of days from date of index admission minus date of birth, divided by 365, rounded down to last full year.
7. Residence census tract in lowest socioeconomic quintile. Binary variable which equals 1 if the residence address belongs to a census tract which is in the first quintile of census tracts that were ranked by socioeconomic status. The variable equals 0, otherwise. Four variables were used to develop a socioeconomic rankings for census tracts: median household income, percent of households

above poverty level in the census tract, percent of residents with age ≥ 18 who reported some college or higher education, and percent of population who were white. The data were reported by the U.S. Census Bureau for the 2000 census for 1,046 census tracts in the 12-county area surrounding Dallas County. Principal components analysis was applied to the variables to to summarize data variation. Census tract scores were used to rank the tracts for partitioning into quintiles.

8. Number of home address changes. The number of address changes that were recorded in the electronic medical record's administrative database from January, 2006 to the index admission date.
9. Medicare, Medicaid, Commercial insurance, Parkland Health Plus, Self-pay or Uninsured, or Other. Each of the variables are binary. A variable equals 1 when the variable represented the payment method for a patient at the time of index admission. The payment methods are mutually exclusive in that a patient is only assigned one payment category. "Dual eligibles", individuals with both Medicare and Medicaid, were assigned to Medicare as their primary payer. "Other" represented payment sources that were not listed in the main categories.
10. History of cocaine. A binary variable which equals 1 when urine toxicology results were positive for the patient in any encounter during the 12-month period prior to index admission. The variable equals 0, otherwise.
11. History of leaving against medical advice. A binary variable which equals 1 when the patient had been reported as leaving a Parkland care site before completion of care at least once during the 12-month period prior to index admission. The care site may have been for either inpatient or outpatient care. The variable equals 0, otherwise.

12. History of missed clinic visit. A binary variable which equals 1 when the patient had been reported as having missed a scheduled Parkland clinic at least once during the 12-month period prior to index admission. The variable equals 0, otherwise.
13. Used a health system pharmacy. A binary variable which equals 1 when the patient had used a pharmacy in the Parkland Health care System at least once during the 12 months prior to index admission. The variable equals 0, otherwise.
14. Number of prior inpatient admissions. Counts the number of inpatient admissions to Parkland during the 12 months prior to the index admission.
15. Number of prior emergency room visits. Counts the number of visits to the Parkland emergency room during the 12 months prior to the index admission.
16. Number of outpatient visits. Counts the number of visits to Parkland outpatient clinics during the 12 months prior to the index admission.
17. Presented to emergency department between 6 am - 6pm for index admission. A binary variable that equals 1 when a patient presented to the Parkland emergency department during the hours 6 am and 6 pm for the index admission.

Appendix C: Covariates in the CMS 30-Day Readmissions Risk-Adjustment Model

The following covariates were obtained, based on whether the patient had specified ICD-9 codes corresponding to the conditions below, listed in any inpatient or outpatient encounter in the year prior to, and including, the index admission. These conditions are listed in Table 10 of the source documentation.[2]

Age-65 (years above 65, continuous), Male, History of CABG, Congestive heart failure, Acute coronary syndrome, Arrhythmias, Cardio-respiratory failure and shock, Valvular and rheumatic heart disease, Vascular or circulatory disease, Chronic atherosclerosis, Other and unspecified heart disease, Hemiplegia, paraplegia, paralysis, functional disability, Stroke, Renal failure, Diabetes and DM complications, Disorders of fluid/electrolyte/acid-base, Other urinary tract disorders, Decubitus ulcer or chronic skin ulcer, Other gastrointestinal disorders, Peptic ulcer, hemorrhage, other specified gastrointestinal disorders, Severe hematological disorders, Nephritis , Dementia and senility, Metastatic cancer and acute leukemia, Cancer, Liver and biliary disease, End-stage renal disease or dialysis, Asthma, Iron deficiency and other/unspecified anemias and blood disease, Pneumonia, Drug/alcohol abuse/dependence/psychosis, Major psych disorders, Depression, Other psychiatric disorders, Fibrosis of lung and other chronic lung disorders, and Protein-calorie malnutrition.

Appendix D: Covariates in the CMS 30-Day Mortality Risk-Adjustment Model

The following covariates were obtained, based on whether the patient had specified ICD-9 codes corresponding to the conditions below, listed in any inpatient or outpatient encounter in the year prior to, and including, the index admission. These conditions are listed in Table 22 of the source documentation.[3]

Age-65 (continuous), Male, History of PTCA, History of CABG, History of heart failure, History of MI, Unstable angina, Chronic atherosclerosis, Cardiopulmonary-respiratory failure and shock, Valvular heart disease, Hypertension, Stroke, Renal failure, COPD, Pneumonia, Diabetes, Protein-calorie malnutrition, Dementia, Hemiplegia, paraplegia, paralysis, functional disability, Peripheral vascular disease, Metastatic cancer, Trauma in last year, Major psych disorders, and Chronic liver disease.

Appendix E. Mortality model derived from the ADHERE (Acute Decompensated Heart Failure) National Registry

The ADHERE mortality model was designed for bedside use in predicting in-hospital mortality from acute decompensated heart failure.[4] Developed through classification and regression tree (CART) analysis, the model is based on three variables that were found to be predictive of inpatient mortality, blood urea nitrogen (BUN) > 43 mg/dL, systolic blood pressure < 115 mmHg, and creatinine > 2.75 mg/dL. The c-statistics reported in the original study were 0.69 and 0.67 for the derivation and validation cohorts, respectively. To compare performance of this model with the other models discussed in this study, separate multivariable logistic regression models for 30-day mortality and 30-day readmissions were fit with the three binary variables as independent variables using our study data.

Appendix F: The Integrated Discrimination Improvement Index

The Integrated Discrimination Improvement (IDI) Index was designed by Pencina, D'Agostino, D'Agostino, Jr, et al to measure the incremental value of a new risk factor or biomarker that may be incorporated into risk assessment algorithms.[5] Its development was in partial response to researchers who sought model performance measures beyond the C statistic to evaluate the usefulness of markers. A major difference between the IDI index and the C statistic is that the latter is based on rankings of predicted risks while the former is based on actual differences of predicted risks, therefore the IDI would be more sensitive to difference magnitude. A simple interpretation of the index is that it measures the difference between two models in the predicted risks for patients who were readmitted within 30 days, after adjusting for model differences for those that were not readmitted. A higher IDI score implies that the new model predicts better than the old model. The index is an arithmetic function of four averages. If we let MPP = mean predicted probability, new = new model, old = old model, r= patient readmitted, nr= patient did not readmit, then

IDI = $[MPP_{new,\,r} - MPP_{old,\,r}] - [MPP_{new,\,nr} - MPP_{old,\,nr}]$. This difference of differences can be tested for significance by using the standard normal distribution.

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* These references are also listed in the references section of the main manuscript text.