Supplemental Online Content

Almarzooq ZI, Song Y, Dahabreh IJ, et al. Comparative effectiveness of percutaneous microaxial left ventricular assist device vs intra-aortic balloon pump or no mechanical circulatory support in patients with cardiogenic shock. *JAMA Cardiol*. Published online June 21, 2023. doi:10.1001/jamacardio.2023.1643

eMethods.

eTable 1. Coding for Acute Myocardial Infarction with Cardiogenic Shock, Percutaneous Coronary Intervention, and Mechanical Circulatory Support using International Classification of Diseases Codes

eTable 2. Patient Level Characteristics Included in the Analysis

eTable 3. Death and All-cause Readmission at 30 Days Post-Percutaneous Coronary Intervention Stratified by Percutaneous Microaxial LVAD versus IABP versus no MCS

eTable 4. Baseline Patient-level and Hospital-level Characteristics of the Study Population Stratified by Percutaneous Microaxial LVAD versus IABP versus no MCS (Propensity Score was Calculated from a Hierarchical Multinomial Regression with Hospital ID Included as a Random Intercept)

eTable 5. Baseline Characteristics of Patients with Acute Myocardial Infarction and Cardiogenic Shock Undergoing Percutaneous Coronary Intervention and their Hospitals Into Five Groups Defined by Quintiles of the Proportion of Percutaneous Microaxial LVAD Use at the Hospital Level (Instrumental Variable Analysis Cohort)

eTable 6. Hospital Groups Defined by Tertiles of Change in Percutaneous Microaxial LVAD Use at the Hospital Level in the Year 2019 versus Year 2016

eTable 7. Changes in Baseline Characteristics in Hospital Groups Defined by Tertiles of Change in Percutaneous Microaxial LVAD During Year 2019 Compared to the Year 2016

eFigure 1. Histogram of Predicted Probability of Receiving Percutaneous Microaxial LVAD Calculated from: A) Primary model B) Sensitivity Model 1 C) Sensitivity Model 2

eFigure 2. Histogram of the Proportion of Patients Presenting with AMICS Undergoing Percutaneous Coronary Intervention Receiving a Percutaneous Microaxial LVAD Device in the Previous Two Years Before the Index Procedure at Each Hospital

eFigure 3. Temporal Trends in Use of Percutaneous Microaxial LVAD as a Percentage of Admissions for AMICS undergoing Percutaneous Coronary Intervention (Overall and at the 5 Highest Volume Centers)

eFigure 4. Histogram of Change in Percutaneous Microaxial LVAD Use by Hospital in the Year 2019 versus Year 2016

eFigure 5. Difference-in-Differences Among Patients in Hospitals with Declining, Moderately Increasing, and Rapidly Increasing Percutaneous Microaxial LVAD use for A) Percentage of Percutaneous Microaxial LVAD use and B) 30-day Mortality

eReferences.

This supplemental material has been provided by the authors to give readers additional information about their work.

eMethods

Study population inclusion and exclusion criteria: We included patients who had revascularization by PCI at any time during the hospitalization; however, patients were excluded if they were treated with MCS prior to the date of PCI, because patients receiving one or more days of hemodynamic support prior to PCI may represent a distinct population of AMICS patients. All patients were required to have at least 1 year of claims data available prior to their index PCI procedure to ascertain comorbidity data. For patients who underwent multiple procedures during the study period, we only considered their first procedure in the analysis. We excluded patients from hospitals that did not offer all treatments (percutaneous microaxial LVAD and IABP). Furthermore, we excluded patients at hospitals that did not have a minimum volume of 10 patients with AMICS receiving PCI over the entire study period based (among Medicare FFS beneficiaries). Patients receiving venous-arterial extra-corporeal membrane oxygenation (VA-ECMO) at the time of PCI were not included in this analysis, as these patients may represent a distinct patient population.

Covariates: Baseline patient sociodemographic factors were obtained on the date of PCI, these include age, sex, race/ethnicity, and dual Medicaid/Medicare enrollment (Supplemental Table 2). Comorbidities were determined using the 27 common chronic condition categories and the 40 other chronic health, mental health, substance abuse, and potentially disabling condition categories available in the chronic condition segments of the Master Beneficiary Summary File. The Chronic Conditions Data Warehouse that compiles these 67 chronic conditions includes algorithms for cross walking ICD-9 codes to ICD-10 codes.[1] Hospital characteristics were retrieved from the AHA Annual Survey File, which includes hospital teaching status, region, and bed capacity. Minority serving hospitals were defined as those in the top 20% of institutions ranked by the proportion of inpatient admissions that were for Black patients during the study period.[2] In addition, we computed the PCI and MCS procedure volumes for each hospital during the study period using the MedPAR file.

Inverse Probability Treatment Weighting (IPTW): This method was first employed to correct for potential confounding bias due to observed characteristics. We used a two-step procedure, both for the two treatment group comparison (percutaneous microaxial LVAD vs. no percutaneous microaxial LVAD) and three treatment comparison (percutaneous microaxial LVAD vs. IABP vs. no MCS).

For the two group comparison (percutaneous microaxial LVAD vs. no percutaneous microaxial LVAD), we used a propensity score model that regressed the binary indicator for treatment group membership on the patient and hospital characteristics described above. In these analyses, patients who received IABP or no MCS were grouped together and considered equivalent with respect to their association with the outcome, because prior trials have shown no mortality benefit with the use of IABP in AMICS.[3] We used hierarchical logistic regression models for the propensity score, with hospital random effects to account for heterogeneity across hospitals. Based on the fitted propensity score model, we obtained the probability of receiving percutaneous microaxial LVAD on the day of PCI versus not for each subject, conditional on patient and hospital characteristics. [4] Inverse probability treatment weights were calculated from the propensity score and each patient's treatment status; weights were truncated to the 99th percentile. We examined overlap in the distributions of the propensity score of the two treatment groups. We also examined balance in

baseline characteristics using standardized mean differences after weighting. We then computed the risk difference in the event rate between the percutaneous microaxial LVAD and no percutaneous microaxial LVAD groups with each subject weighted by the inverse of the estimated probability of the treatment they actually received.

We obtained 95% confidence intervals for both estimated risks and risk differences using the non-parametric bootstrap with 500 iterations. For each bootstrap sample, we re-estimated propensity score model, re-calculated the inverse probability weights, the counterfactual outcome risks in the pseudo-population under each treatment strategies, and the risk difference comparing treatments. For each of these statistics, the 2.5th and 97.5th percentile values over the bootstrap distribution were reported as the 95% confidence interval (percentile interval).

For the three group comparison (percutaneous microaxial LVAD vs. IABP vs. no MCS), generalized logit link functions were utilized to estimate the predicted probability of receiving each treatment (percutaneous microaxial LVAD, IABP, or no MCS). The propensity score was obtained using a multinomial regression model with treatment as the response variable and the same covariates used as predictors. Each observation was then weighted by the inverse of the estimated probability of the treatment actually received. We used the estimated weights to estimate pairwise risk differences comparing different treatments. Informally, the weights were calculated as the inverse of the (estimated) probability of receiving the treatment actually received. Trimmed weights, risks, risk differences, and corresponding confidence (percentile) intervals (over 500 bootstrap resamples) for each pairwise comparison of the three treatment strategies were calculated similarly as in the analyses comparing percutaneous microaxial LVAD vs. no percutaneous microaxial LVAD. SAS 9.4 Procedure Proc Glimmix was used to estimate the propensity scores models.

Instrumental variable analyses: We used instrumental variable (IV) methods to address confounding by unmeasured variables. An IV analysis takes advantage of "natural" variation in the use of the percutaneous microaxial LVAD device to estimate the effect of the device on outcomes. We treated the percentage of percutaneous microaxial LVAD use in all AMICS patients undergoing PCI in previous 2 years at a given institution as the instrument for each index procedure with the following assumptions. An institution's prior use of percutaneous microaxial LVAD was a strong predictor of the probability of using the device for subsequent hospitalizations, suggesting that the relevance assumption held (relevance assumption). To indirectly assess the exchangeability and exclusion restriction assumptions, we examined standardized mean differences in patient and hospital characteristics among AMICS patients across quintiles of the IV. Within quintiles of the IV, observing significant differences in prognostically important patient or hospital characteristics across quintiles of hospital percutaneous microaxial LVAD use would therefore suggest potential violations of IV assumptions. Under an additional assumption that no patient's treatment responds opposite to "encouragement" by the instrument ("monotonicity"), IV approaches can estimate treatment effects among individuals whose treatment responds according to the instrument ("compliers"). When, as in our analyses, the model for IV analyses includes covariates, the effect estimated is a weighted average of complier effects in different covariate-defined subgroups, provided additional assumptions regarding model specification also hold.

We first calculated the percentage of percutaneous microaxial LVAD use at each practice in the prior 2 years for each index procedure. We intended to split the study cohort into 5 approximately equally sized IV stratum based on the instrument. However, because of the large number of individuals from the institutions where no percutaneous microaxial LVAD had been

applied in the previous two years, 5 equally sized groups could not be created. We examined the balance of baseline patient characteristics between the top and bottom quintile of the instrumental variable using standardized differences, and qualitatively across all groups.

We used 2-stage least-squares methods to estimate risk dfferences comparing treatment groups, adjusted for the patient and hospital-level variables. [5] In the first stage, we used linear regression to predict percutaneous microaxial LVAD use as a function of the instrumental variable and patient and hospital-level characteristics. This allowed us to evaluate the relevance assumption (F-statistic cutoff 10). In the second stage, we used a second linear regression to predict the outcome based on the probability of percutaneous microaxial LVAD use, as estimated in the first stage model, and the patient- and hospital-level variables. The parameter in the second stage model was the risk difference comparing percutaneous microaxial LVAD vs. no percutaneous microaxial LVAD . We obtained 95% Wald confidence intervals for this parameter. SAS 9.4 procedure Proc Syslin was used for this method implementation.

Instrumented Difference-in-Differences Analysis: We evaluated temporal trends of percutaneous microaxial LVAD use at each practice and conducted an instrumented difference-in-differences (DDIV) analysis to assess the causal effect of percutaneous microaxial LVAD on short term outcomes. We first defined the pre-growth period as 10/1/2015 – 9/30/2016 (labeled "2016" in the main text) and the post-growth period as 10/1/2018 – 9/30/2019 (labeled "2019" in the main text). Hospitals with more than 5 patients treated in the study cohort in both the year 2016 and year 2019 were included in this analysis. Since this is a hospital-level analysis, hospitals were split into 3 categories – declining (<0%), moderately increasing (0-20%), and rapidly increasing (>20%), based on the difference of percutaneous microaxial LVAD use during 2019 compared to 2016 (**Supplemental Table 6**).

For each pairwise comparison between the declining, moderately increasing, and increasing hospital groups the numerator of the DDIV estimand is the difference-in-differences of outcomes comparing any two hospital types, and the denominator is the difference-in-differences of percutaneous microaxial LVAD use comparing any two hospital types. To calculate the numerator and denominator, we estimated two separate linear mixed effects regression models, fit on the patient-level, with hospital type, pre- vs. post-period, and interaction between hospital type and pre vs. post-period, as well as patient and hospital-level characteristics included as predictors. Difference-in-differences of outcomes and difference-in-differences of percutaneous microaxial LVAD use comparing each pair of hospital types were estimated from the linear mixed effects models and the DDIV estimand was the ratio of difference-in-differences of outcomes by difference-in-differences of percutaneous microaxial LVAD use. We generated 95% confidence intervals using the nonparametric bootstrap with 500 resamples. We used SAS 9.4 procedure Proc Mixed to implement this method.

Grace Period Design: Grace period method allows for comparing treatments that can be given within a period of time (e.g., 2 days) while addressing both immortal time bias and baseline confounding.[6,7] This method includes 3 steps: cloning, (artificial) censoring, and weighting.

In the cloning step, we created 4 clones (exact copies) of each patient, one for each treatment strategy: percutaneous microaxial LVAD , IABP, no MCS, and all other treatment strategies. The category for all other treatment strategies includes patients who received both percutaneous microaxial LVAD and IABP during the same day or received VA-ECMO during

the grace period. To include time-varying covariates (like intubation and vasopressor use) during the grace period, we expanded each copy to one record per day within grace period, for example, with 2-days grace period, we have two records for each of the four treatment strategy copies, one record for grace period day 1, and the other record for grace period day 2. We also expanded the day 3 to day 30 into one record per day, for the post grace period days. Instead of duplicating to four copies per day, only one copy per day was kept in the data for each patient, because each individual treatment strategy was completely determined at the end of the grace period. Starting from day 3, at most one clone copy from each treatment strategy can still contribute person-time to the analysis.

In the censoring step, clones assigned to a treatment strategy are censored when they are no longer eligible for that treatment strategy (i.e., when they receive a specific treatment strategy or the grace period ends). Potential bias due to censoring is addressed by inverse probability of censoring weighting using time-fixed and time-varying variables as predictors of treatment initiation during the grace period. In this step, censoring indicators for each treatment strategy at each grace period day were created. For example, if a patient did not receive any device on day 1 and received percutaneous microaxial LVAD on day 2, then each clone of that patient was compatible with its assigned strategy on day 1 (and none were censored), the clone assigned to the percutaneous microaxial LVAD strategy was still compatible with that strategy on day 2 (and was also not censored), but all other clones were no longer compatible with their assigned strategies (and were thus censored starting on day 2). The censoring indicators for this example re shown in the table below.

ID	Treatment Strategy to Which the Clone was Assigned	Day	Censored
01-001	Percutaneous microaxial LVAD	1	No
01-001	Percutaneous microaxial LVAD	2	No
01-001	IABP	1	No
01-001	IABP	2	Yes
01-001	Other	1	No
01-001	Other	2	Yes
01-001	No MCS	1	No
01-001	No MCS	2	Yes

In the weighting step, for each treatment strategy and each day, among individuals who have not initiated any device previously (percutaneous microaxial LVAD , IABP, and Other), we estimated the probability of not being censored. Multinomial logistic regression was performed separately for each grace period day, with four treatment groups included as the response variable, and patient and hospital characteristics (both time invariant and time-varying covariates) as predictor variables. Weights at each day were calculated as the inverse of the estimated probability of not being censored .The estimated weights were then truncated at the 99th percentile. [8]

To estimate the causal risk difference, we used a weighted discrete time pooled logistic regression model. The model included a quadratic form of time and an interaction between treatment strategy and time to allow for non-linear association between logit of outcome and time. Patient- and hospital-level characteristics, including both time-invariant and time-varying covariates, were included in the model. Finally, we used the estimated model parameters to estimate 30-day risks and risk differences. We obtained 95% confidence intervals using a nonparametric bootstrap with 500 resamples. We used SAS 9.4 Procedure Proc Logistic to

estimate models for the probability of treatment initiation (and to estimate the probability of censoring for different treatment strategies) and SAS procedure Proc Genmod to estimate the pooled logistic outcome regression models.

eTable 1. Coding for Acute Myocardial Infarction with Cardiogenic Shock, Percutaneous Coronary Intervention, and Mechanical Circulatory Support using International Classification of Diseases Codes.

Variables	ICD-10-CM or ICD-10-PCS Code
Cardiogenic Shock	R57.0 (any position)
AMI	I21.01, I21.02, I21.09, I21.11 I21.19, I21.21, I21.29, I21.3, I21.4 (primary position only)
PCI	0270346, 027034Z, 02703D6, 02703DZ, 02703Z6, 02703ZZ 0270446, 027044Z, 02704D6, 02704DZ, 02704Z6, 02704ZZ 0271346, 027134Z, 02713D6, 02713DZ, 02713Z6, 02713ZZ 0271446, 027144Z, 02714D6, 02714DZ, 02714Z6, 02714ZZ 0272346, 027234Z,02723D6, 02723DZ, 02723Z6, 02723ZZ 0272446, 027244Z, 02724D6, 02724DZ, 02724Z6, 02724ZZ 0273346, 027334Z, 02733D6, 02733DZ, 02733Z6, 02733ZZ 0273446, 027344Z, 02734D6, 02734DZ, 02734Z6, 02734ZZ
MCS – Percutaneous Microaxial LVAD (Impella)	5A0221D, 5A0211D
MCS – IABP	5A02210, 5A02110
MCS – VA-ECMO	5A1522G

ICD-10-CM, International Classification of Diseases, Clinical Modification, Tenth Revision; ICD-10-PCS, International Classification of Diseases, Procedure Coding System; AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; MCS, mechanical circulatory support; IABP, intra-aortic balloon pump; VA-ECMO, veno-arterial extracorporeal membrane oxygenation.

eTable 2. Patient Level Characteristics Included in the Analysis.

Non-Chronic Condition File Variables	Other Chronic and Potentially Disabling Conditions File Variables
Age	ADHD, Conduct Disorders, and Hyperkinetic Syndrome
Male	Alcohol Use Disorders
Race (White, Black, Other)	Anxiety Disorders
Presenting AMI type (STEMI, NSTEMI)	Autism Spectrum Disorders
Cardiac Arrest on Presentation	Bipolar Disorder
Prior PCI	Cerebral Palsy
Prior CABG	Cystic Fibrosis and Other Metabolic Developmental Disorders
Intubation	Depressive Disorders
Vasopressor Use	Drug Use Disorders
Chronic Conditions File Variables	Epilepsy
Acquired Hypothyroidism	Fibromyalgia, Chronic Pain and Fatigue
AMI	Human Immunodeficiency Virus and/or Acquired Immunodeficiency Syndrome
Alzheimer's Disease	Intellectual Disabilities and Related Conditions
Alzheimer's Disease, Related Disorders, or Senile Dementia	Learning Disabilities
Anemia	Leukemias and Lymphomas
Asthma	Liver Disease, Cirrhosis and Other Liver Conditions
Atrial Fibrillation	Migraine and Chronic Headache
Benign Prostatic Hyperplasia	Mobility Impairments
Cancer, Colorectal	Personality Disorders
Cancer, Endometrial	Post-Traumatic Stress Disorder
Cancer, Breast	Pressure and Chronic Ulcers
Cancer, Lung	Schizophrenia
Cancer, Prostate	Schizophrenia and Other Psychotic Disorders
Cataract	Sensory - Blindness and Visual Impairment
Chronic Kidney Disease	Sensory - Deafness and Hearing Impairment
Chronic Obstructive Pulmonary Disease	Sickle Cell Disease
Depression	Spina Bifida and Other Congenital Anomalies of the Nervous System
Diabetes	Spinal Cord Injury
Glaucoma	Tobacco Use
Heart Failure	Traumatic Brain Injury and Nonpsychotic Mental Disorders due to Brain Damage
Hip / Pelvic Fracture	Viral Hepatitis

Hyperlipidemia	Muscular Dystrophy
Hypertension	Multiple Sclerosis and Transverse Myelitis
Ischemic Heart Disease	Obesity
Osteoporosis	Opioid Use Disorder
Rheumatoid Arthritis / Osteoarthritis	Other Developmental Delays
Stroke / TIA	Peripheral Vascular Disease

AMI, acute myocardial infarction; ADHD, attention deficit/hyperactivity disorder; STEMI, ST-elevation myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; TIA, transient ischemic attack.

eTable 3. Death and All-cause Readmission at 30 Days Post-Percutaneous Coronary Intervention Stratified by Percutaneous Microaxial LVAD versus IABP versus no MCS.

	Death at 30 Days					Death and All-cause Readmission at 30 Days				
Study Methods	**Percutaneous Microaxial LVAD**	**No MCS**	**IABP**	**Difference [95% CI] Percutaneous Microaxial LVAD – no MCS**	**Difference [95% CI] Percutaneous Microaxial LVAD – IABP**	**Percutaneous Microaxial LVAD**	**No MCS**	**IABP**	**Difference [95% CI] Percutaneous Microaxial LVAD – no MCS**	**Difference [95% CI] Percutaneous Microaxial LVAD – IABP**
Unweighted	56.4%	35.5%	41.4%	21.0% [19.2%, 22.7%]	15.1% [13.1%, 17.0%]	60.8%	42.4%	47.6%	18.3% [16.6%, 20.1%]	13.2% [11.3%, 15.1%]
IPTW Analysis	52.7% [51.0%, 54.4%]	37.2% [36.2%, 38.2%]	41.3% [40.0%, 42.7%]	15.5% [13.4%, 17.6%]	11.4% [9.1%, 13.7%]	57.8% [56.1%, 59.5%]	43.9% [42.9%, 44.9%]	47.8% [46.4%, 49.1%]	13.9% [11.8%, 15.9%]	10.0% [7.8%, 12.2%]
Grace period Analysis (2-day grace period)	56.9% [48.1%, 65.7%]	34.0% [32.0%, 36.0%]	45.5% [41.4%, 49.5%]	22.9% [14.4%, 31.4%]	11.4% [2.1%, 20.7%]	62.5% [53.5%, 71.5%]	39.9% [37.6%, 42.1%]	50.9% [46.6%, 55.2%]	22.6% [13.9%, 31.4%]	11.6% [2.3%, 20.9%]

95% CI obtained from the non-parametric bootstrap with 500 iterations.
IPTW, inverse probability of treatment weighting; IABP, intra-aortic balloon pump, MCS; mechanical circulatory support.
The propensity score was estimated using a hierarchical logistic regression model with hospital ID included as a random intercept.

eTable 4. Baseline Patient-level and Hospital-level Characteristics of the Study Population Stratified by Percutaneous Microaxial LVAD versus IABP versus no MCS (*Propensity Score was Calculated from a Hierarchical Multinomial Regression with Hospital ID Included as a Random Intercept*).

	Pre-weighting					Post-weighting				
Subject Characteristic	**Percutaneous Microaxial LVAD (4,063 individuals)**	**No MCS (12,451 individuals)**	**IABP (6,964 individuals)**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**	**Percutaneous Microaxial LVAD**	**No MCS**	**IABP**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**
Demographics										
Age (yrs)										
Mean ± SD	72.8±9.3	74.2±10.1	73.8±9.8	-15.0	-11.0	73.4±21.7	73.9±13.8	73.8±17.8	-2.3	-1.9
Male	67.7%	56.9%	63.5%	22.4	8.8	63.2%	61.1%	60.8%	4.3	5.0
Race										
White	85.4%	87.4%	87.2%	-5.7	-5.3	86.5%	86.9%	87.0%	-1.2	-1.5
Black	7.4%	6.8%	7.0%	2.6	1.8	7.2%	7.0%	7.0%	0.9	0.8
Other	7.2%	5.9%	5.8%	5.2	5.6	6.3%	6.1%	6.0%	0.7	1.2
Presenting AMI type										
STEMI	63.2%	69.5%	76.4%	-13.4	-29.1	67.0%	70.1%	70.6%	-6.5	-7.7
NSTEMI	36.8%	30.5%	23.6%	13.4	29.1	33.0%	29.9%	29.4%	6.5	7.7
Cardiac Arrest on Presentation	12.5%	9.3%	11.4%	10.3	3.4	11.5%	10.6%	10.5%	2.8	3.1
Prior PCI	14.2%	14.8%	13.2%	-1.7	3.0	14.6%	14.3%	14.1%	1.0	1.4
Prior CABG	2.9%	3.6%	3.1%	-4.4	-1.6	3.4%	3.3%	3.4%	0.3	-0.0
Chronic Conditions File Variables										
Acute Myocardial Infarction	33.9%	22.2%	23.9%	26.3	22.2	26.5%	24.7%	24.7%	4.2	4.2
Alzheimer's Disease	2.6%	4.4%	3.2%	-9.5	-3.1	3.3%	3.7%	3.6%	-2.0	-1.4
Alzheimer's Dsease and Rltd Disorders or Senile Dementia	10.9%	15.0%	11.8%	-12.2	-2.6	12.6%	13.3%	13.1%	-2.2	-1.6
Atrial Fibrillation	15.2%	17.2%	14.1%	-5.5	3.2	15.8%	16.1%	15.6%	-0.8	0.5
Cataract	52.8%	58.0%	54.5%	-10.4	-3.4	55.1%	55.9%	55.5%	-1.6	-0.7
Chronic Kidney Disease	50.1%	49.4%	43.5%	1.3	13.3	48.5%	47.8%	47.7%	1.3	1.6
Chronic Obstructive Pulmonary Disease	28.9%	35.5%	28.6%	-14.2	0.7	31.7%	32.2%	32.2%	-1.0	-0.9
Heart Failure	58.9%	50.4%	48.6%	17.3	20.9	53.7%	51.6%	50.8%	4.3	5.9
Diabetes	50.3%	47.3%	45.4%	6.0	9.7	48.2%	47.3%	47.1%	1.7	2.2
Glaucoma	18.7%	20.3%	18.7%	-4.0	-0.2	19.4%	19.5%	19.5%	-0.2	-0.4
Hip/Pelvic Fracture	2.4%	4.2%	2.9%	-9.7	-3.0	3.0%	3.5%	3.5%	-2.4	-2.4
Ischemic Heart Disease	95.4%	96.0%	95.5%	-3.1	-0.5	95.6%	95.7%	95.5%	-0.9	0.1
Depression	30.4%	34.6%	30.3%	-9.1	0.2	32.2%	32.5%	32.4%	-0.8	-0.6
Osteoporosis	11.5%	16.7%	14.3%	-15.0	-8.2	13.5%	14.9%	14.8%	-4.1	-3.8

	Pre-weighting					Post-weighting				
Subject Characteristic	**Percutaneous Microaxial LVAD (4,063 individuals)**	**No MCS (12,451 individuals)**	**IABP (6,964 individuals)**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**	**Percutaneous Microaxial LVAD**	**No MCS**	**IABP**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**
Rheumatoid Arthritis / Osteoarthritis	46.9%	54.4%	48.0%	-15.0	-2.3	49.6%	50.9%	51.0%	-2.5	-2.7
Stroke / Transient Ischemic Attack	17.0%	19.5%	17.1%	-6.5	-0.3	18.4%	18.3%	18.1%	0.2	0.9
Breast Cancer	2.6%	3.7%	3.5%	-6.2	-5.1	3.3%	3.4%	3.5%	-0.6	-1.3
Colorectal Cancer	2.0%	2.8%	2.8%	-5.3	-4.8	2.1%	2.8%	2.7%	-4.4	-3.6
Prostate Cancer	6.2%	5.4%	6.5%	3.2	-1.3	6.4%	5.6%	5.8%	3.2	2.5
Lung Cancer	1.3%	2.2%	2.3%	-7.2	-7.5	1.4%	2.1%	2.3%	-5.9	-7.2
Endometrial Cancer	0.3%	0.6%	0.7%	-4.6	-5.3	0.3%	0.5%	0.6%	-3.4	-3.9
Anemia	52.9%	55.8%	51.4%	-5.7	3.1	53.4%	53.9%	53.9%	-1.0	-1.0
Asthma	12.6%	13.9%	12.0%	-3.8	1.9	12.9%	13.0%	13.0%	-0.4	-0.4
Hyperlipidemia	77.6%	77.7%	75.1%	-0.1	6.0	76.9%	76.9%	76.6%	-0.0	0.7
Benign Prostatic Hyperplasia	23.1%	21.1%	22.9%	4.8	0.3	22.6%	22.1%	21.8%	1.1	1.8
Hypertension	80.9%	82.4%	78.6%	-3.9	5.6	80.7%	81.0%	80.8%	-0.9	-0.3
Acquired Hypothyroidism	22.5%	25.7%	23.2%	-7.4	-1.6	23.7%	24.3%	24.5%	-1.4	-1.8
Hospital Characteristics										
Hospital Size (Number of Beds)										
Mean ± SD	476.1±345.9	450.9±302.2	457.6±318.1	7.8	5.6	467.9±778.0	464.7±444.7	460.1±576.1	0.5	1.1
Ownership										
For Profit	17.1%	15.2%	14.6%	5.2	7.0	15.8%	15.4%	15.5%	0.9	0.7
Private Nonprofit	73.1%	75.5%	76.6%	-5.6	-8.0	74.7%	75.2%	75.4%	-1.0	-1.5
Public	9.8%	9.3%	8.8%	1.8	3.2	9.5%	9.4%	9.1%	0.4	1.4
Teaching Status										
Metropolitan Teaching	72.4%	71.0%	71.6%	3.0	1.6	71.6%	71.8%	71.5%	-0.5	0.3
Metropolitan Non-teaching	27.2%	28.7%	28.1%	-3.3	-2.0	28.1%	27.9%	28.3%	0.5	-0.4
Rural	0.4%	0.3%	0.3%	2.3	2.8	0.3%	0.3%	0.3%	0.4	0.6
JCAHO Accredited	85.9%	85.9%	85.3%	0.0	1.9	85.8%	85.5%	85.5%	0.7	0.7
Region										
Northeast	13.4%	13.3%	16.6%	0.0	-9.1	14.5%	14.4%	14.5%	0.3	-0.1
Midwest	17.6%	17.6%	16.8%	0.2	2.2	17.5%	17.3%	17.4%	0.6	0.5
South	50.5%	48.8%	48.9%	3.4	3.0	49.0%	49.3%	48.9%	-0.7	0.1
West	18.5%	20.3%	17.6%	-4.5	2.3	19.0%	19.1%	19.2%	-0.0	-0.5
Minority Serving Hospital	20.8%	17.7%	18.6%	7.9	5.5	18.5%	18.4%	18.5%	0.3	0.0
Hospital ADI										
Mean ± SD	53.2±21.3	52.8±21.4	52.9±22.0	1.9	1.3	53.0±49.5	53.0±29.5	52.9±39.1	0.0	0.3
Dual Enrollee	17.6%	18.7%	16.5%	-2.7	3.1	17.7%	17.7%	17.8%	0.2	-0.3
Intubation	57.1%	31.6%	44.5%	53.1	25.4	43.4%	40.4%	40.8%	6.1	5.3
Vasopressor	15.2%	8.7%	11.8%	20.0	10.0	11.3%	10.7%	10.9%	2.0	1.2

	Pre-weighting					Post-weighting				
Subject Characteristic	**Percutaneous Microaxial LVAD (4,063 individuals)**	**No MCS (12,451 individuals)**	**IABP (6,964 individuals)**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**	**Percutaneous Microaxial LVAD**	**No MCS**	**IABP**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**
RHC/PA Catheter	14.7%	3.6%	7.8%	39.4	22.1	7.6%	6.9%	6.8%	3.0	3.4
Other Chronic Conditions File Variables										
ADHD and Other Conduct Disorders	1.2%	0.9%	1.1%	2.4	0.8	1.2%	0.9%	1.2%	3.1	0.0
Alcohol Use Disorders	4.4%	5.7%	4.6%	-5.9	-0.9	5.1%	5.2%	5.2%	-0.3	-0.5
Anxiety Disorders Indicator	23.4%	27.2%	22.5%	-8.6	2.2	24.6%	25.1%	24.9%	-1.1	-0.7
Autism Indicator	0.0%	0.0%	0.1%	-1.2	-2.1	0.0%	0.0%	0.1%	0.2	-1.1
Bipolar Disorder	3.3%	4.5%	3.5%	-6.6	-1.4	3.5%	4.1%	4.0%	-3.3	-2.6
Traumatic Brain Injury and Nonpsychotic Mental Disorders due to Brain Damage	0.8%	1.3%	0.8%	-4.9	-0.4	1.0%	1.2%	0.9%	-2.3	0.2
Cerebral Palsy	0.1%	0.3%	0.2%	-3.4	-2.5	0.1%	0.3%	0.2%	-3.6	-2.3
Cystic Fibrosis and Other Metabolic Developmental Disorders	1.9%	2.0%	2.1%	-0.4	-1.4	1.8%	1.8%	2.3%	0.5	-2.9
Diagnosis and Procedure Basis for OUD	23.5%	27.2%	23.0%	-8.6	1.1	25.0%	25.3%	25.1%	-0.6	-0.4
Drug Use Disorder	5.7%	7.1%	5.4%	-5.6	1.5	6.0%	6.3%	6.3%	-1.0	-1.3
Epilepsy	3.2%	3.4%	3.0%	-1.0	1.3	3.1%	3.3%	3.1%	-1.3	-0.1
Fibromyalgia, Chronic Pain and Fatigue	29.5%	33.5%	29.4%	-8.5	0.3	31.3%	31.3%	31.5%	0.0	-0.4
Sensory - Deafness and Hearing Impairment	11.5%	12.8%	11.9%	-4.0	-1.4	12.1%	12.2%	12.3%	-0.1	-0.5
Viral Hepatitis (General)	2.3%	2.5%	2.0%	-1.4	1.9	2.3%	2.5%	2.3%	-1.5	-0.3
HIV/AIDS	0.6%	0.4%	0.4%	2.6	2.4	0.5%	0.4%	0.4%	2.6	1.9
Intellectual Disabilities and Related Conditions	0.5%	0.5%	0.7%	-0.2	-1.9	0.5%	0.5%	0.6%	-0.0	-1.5
Learning Disabilities	0.1%	0.2%	0.2%	-2.0	-2.2	0.1%	0.2%	0.3%	-2.8	-3.3

	Pre-weighting					Post-weighting				
Subject Characteristic	**Percutaneous Microaxial LVAD (4,063 individuals)**	**No MCS (12,451 individuals)**	**IABP (6,964 individuals)**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**	**Percutaneous Microaxial LVAD**	**No MCS**	**IABP**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**
Leukemias and Lymphomas	2.2%	2.4%	2.5%	-1.4	-2.5	2.1%	2.2%	2.6%	-0.5	-3.1
Liver Disease, Cirrhosis and Other Liver Conditions (excluding Hepatitis)	11.4%	11.3%	9.6%	0.6	6.0	10.9%	10.8%	10.6%	0.3	0.9
Migraine and other Chronic Headache	4.8%	5.1%	4.0%	-1.4	3.8	5.3%	4.7%	4.7%	2.8	2.8
Mobility Impairments	6.6%	7.3%	6.1%	-2.4	2.4	7.0%	6.8%	6.6%	0.7	1.5
Multiple Sclerosis and Transverse Myelitis	0.5%	0.7%	0.6%	-2.7	-2.2	0.4%	0.6%	0.7%	-2.8	-3.8
Muscular Dystrophy	0.0%	0.1%	0.1%	-1.2	-1.9	0.0%	0.1%	0.1%	-1.5	-2.7
Obesity	28.0%	27.7%	24.7%	0.7	7.5	27.8%	26.8%	26.6%	2.3	2.7
Other Developmental Delays	0.1%	0.1%	0.1%	-0.2	-0.9	0.1%	0.1%	0.1%	-1.1	-1.8
Overarching OUD Disorder (Any of the Three Sub-Indicators)	3.1%	4.1%	2.9%	-5.0	1.5	3.5%	3.6%	3.3%	-0.2	1.0
Diagnosis and Procedure Basis for OUD	2.4%	3.0%	2.1%	-3.3	2.2	2.8%	2.6%	2.5%	1.4	1.4
Opioid-Related Hospitalization or ED	2.0%	2.9%	1.9%	-5.6	1.4	2.2%	2.6%	2.1%	-2.3	0.6
Use of Medication-Assisted Treatment (MAT)	0.1%	0.4%	0.3%	-4.1	-2.7	0.2%	0.3%	0.3%	-3.4	-3.4
Personality Disorders	1.9%	1.7%	1.6%	1.6	2.8	2.3%	1.6%	1.7%	5.1	3.8
Post-Traumatic Stress Disorder	1.5%	1.4%	1.3%	1.1	1.3	1.5%	1.3%	1.5%	1.8	0.1
Peripheral Vascular Disease	30.5%	33.9%	27.9%	-7.2	5.6	31.3%	31.4%	31.3%	-0.2	-0.0
Sickle Cell Disease	0.0%	0.0%	0.0%	0.0	-1.0	0.0%	0.0%	0.1%	1.0	-1.0

	Pre-weighting					Post-weighting				
Subject Characteristic	**Percutaneous Microaxial LVAD (4,063 individuals)**	**No MCS (12,451 individuals)**	**IABP (6,964 individuals)**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**	**Percutaneous Microaxial LVAD**	**No MCS**	**IABP**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – no MCS**	**Standardized Difference [x100] Percutaneous Microaxial LVAD – IABP**
Schizophrenia	1.3%	1.4%	1.3%	-1.1	0.2	1.3%	1.3%	1.3%	0.1	-0.1
Schizophrenia and Other Psychotic Disorders	3.8%	4.7%	3.7%	-4.4	0.5	4.2%	4.3%	4.0%	-0.4	1.2
Spina Bifida and Other Congenital Anomalies of the Nervous System	0.1%	0.2%	0.2%	-3.3	-3.0	0.2%	0.2%	0.2%	-1.6	-1.6
Spinal Cord Injury	1.1%	1.4%	1.1%	-2.5	0.7	1.1%	1.3%	1.2%	-2.0	-1.3
Tobacco Use Disorders	21.4%	26.2%	21.4%	-11.3	0.0	23.4%	24.0%	24.0%	-1.3	-1.3
Pressure Ulcers and Chronic Ulcers	12.9%	13.9%	10.8%	-3.1	6.5	12.8%	12.7%	12.3%	0.0	1.3
Sensory - Blindness and Visual Impairment	1.8%	2.3%	1.8%	-3.6	-0.1	2.0%	2.2%	2.0%	-1.5	-0.2

IABP, intra-aortic balloon pump; yrs, years; SD, standard deviation; AMI, acute myocardial infarction; STEMI, ST-elevation myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass Graft; RHC/PA catheter, right heart / pulmonary artery catheter; ADI, area deprivation index; ADHD, attention deficit hyperactivity disorder; OUD, opioid use disorder.

eTable 5. Baseline Characteristics of Patients with Acute Myocardial Infarction and Cardiogenic Shock Undergoing Percutaneous Coronary Intervention and their Hospitals Into Five Groups Defined by Quintiles of the Proportion of Percutaneous Microaxial LVAD Use at the Hospital Level (*Instrumental Variable Analysis Cohort*).

Subject Characteristic	Bottom fifth (7861 individuals)	Second fifth (1370 individuals)	Middle fifth (5181 individuals)	Fourth fifth (4032 individuals)	Top fifth (4568 individuals)	Standardized Difference (x100) Bottom fifth – top fifth
Demographics						
Age (yrs)						
Mean ± SD	73.9±9.9 (7861)	74.0±9.4 (1370)	73.9±10.0 (5181)	73.8±9.8 (4032)	73.8±9.9 (4568)	0.9
Median (Q1, Q3)	73.0 (67.0,81.0)	74.0 (68.0,81.0)	73.0 (67.0,81.0)	73.0 (67.5,81.0)	73.0 (67.0,81.0)	
(Min, Max)	(30.0,104.0)	(34.0,101.0)	(33.0,102.0)	(29.0,106.0)	(32.0,100.0)	
Male	60.8%	60.9%	61.0%	61.0%	60.3%	1.1
Race						
White	87.0%	88.7%	88.7%	86.9%	85.0%	5.9
Black	6.7%	5.5%	5.9%	7.6%	8.4%	-6.5
Other	6.3%	5.8%	5.4%	5.5%	6.6%	-1.3
Presenting AMI type						
STEMI	70.1%	71.5%	71.4%	71.6%	68.8%	2.7
NSTEMI	29.9%	28.5%	28.6%	28.4%	31.2%	-2.7
Cardiac Arrest on Presentation	11.8%	12.0%	10.3%	10.3%	8.3%	11.6
Prior PCI	14.9%	12.1%	13.7%	14.4%	13.8%	3.2
Prior CABG	3.4%	3.6%	3.5%	3.2%	3.1%	1.7
Chronic Conditions File Variables (27)						
Acute Myocardial Infarction	25.9%	20.9%	23.2%	24.4%	25.0%	2.1
Alzheimer's Disease	3.8%	3.4%	3.8%	3.6%	3.6%	0.9
Alzheimer's Dsease and Rltd Disorders or Senile Dementia	13.5%	12.2%	12.8%	13.5%	13.7%	-0.5
Atrial Fibrillation	16.3%	15.5%	15.7%	15.2%	16.4%	-0.2
Cataract	56.3%	58.8%	55.8%	54.4%	56.6%	-0.6
Chronic Kidney Disease	47.6%	45.5%	47.3%	47.9%	49.1%	-3.0
Chronic Obstructive Pulmonary Disease	33.4%	32.0%	31.7%	30.8%	32.4%	2.2
Heart Failure	51.5%	52.5%	49.5%	50.4%	53.4%	-3.9
Diabetes	47.4%	45.8%	46.5%	46.9%	48.1%	-1.5
Glaucoma	19.5%	18.6%	19.4%	18.8%	20.4%	-2.1
Hip/Pelvic Fracture	3.4%	3.4%	3.7%	3.4%	3.6%	-1.0
Ischemic Heart Disease	96.1%	95.9%	95.8%	95.7%	95.2%	4.3
Depression	32.6%	31.2%	32.6%	32.1%	33.3%	-1.6
Osteoporosis	15.0%	14.5%	14.4%	15.2%	16.0%	-2.8
Rheumatoid Arthritis / Osteoarthritis	51.2%	50.4%	51.4%	50.9%	51.4%	-0.4
Stroke / Transient Ischemic Attack	18.9%	18.2%	18.7%	17.4%	18.0%	2.3
Breast Cancer	3.6%	3.6%	3.0%	3.7%	3.5%	0.8
Colorectal Cancer	2.6%	2.8%	2.7%	2.5%	2.8%	-1.8
Prostate Cancer	6.2%	6.6%	5.9%	5.4%	5.4%	3.8
Lung Cancer	2.2%	3.0%	1.8%	1.9%	2.1%	0.3
Endometrial Cancer	0.7%	0.7%	0.6%	0.5%	0.3%	5.4

Subject Characteristic	Bottom fifth (7861 individuals)	Second fifth (1370 individuals)	Middle fifth (5181 individuals)	Fourth fifth (4032 individuals)	Top fifth (4568 individuals)	Standardized Difference (x100) Bottom fifth – top fifth
Anemia	54.2%	52.6%	53.1%	53.8%	55.3%	-2.1
Asthma	12.9%	12.1%	12.5%	13.3%	14.2%	-3.9
Hyperlipidemia	77.0%	76.6%	76.7%	77.2%	77.1%	-0.3
Benign Prostatic Hyperplasia	22.7%	22.0%	21.4%	21.3%	22.1%	1.6
Hypertension	81.6%	82.8%	80.4%	79.9%	81.1%	1.4
Acquired Hypothyroidism	24.3%	22.6%	24.6%	24.1%	25.1%	-1.8
Hospital Characteristics						
Hospital Size (Number of Beds)						
Mean ± SD	392.1±229.5 (7861)	563.7±334.7 (1370)	483.7±313.6 (5181)	483.7±353.3 (4032)	502.2±378.0 (4568)	-35.2
Median (Q1, Q3)	333.0 (231.0,509.0)	527.0 (311.0,713.0)	405.0 (277.0,625.0)	391.0 (263.0,613.0)	413.5 (263.0,609.0)	
(Min, Max)	(32.0,2013.0)	(44.0,1414.0)	(32.0,2829.0)	(47.0,2829.0)	(32.0,2829.0)	
Ownership						
For Profit	16.0%	14.8%	11.7%	14.3%	18.7%	-7.3
Private Nonprofit	75.0%	80.1%	77.6%	77.5%	71.3%	8.4
Public	9.0%	5.0%	10.7%	8.2%	9.9%	-3.3
Teaching Status						
Metropolitan Teaching	67.5%	80.6%	72.8%	73.5%	74.5%	-15.5
Metropolitan Non-teaching	32.4%	19.4%	27.0%	26.4%	24.5%	17.6
Rural	0.1%	0.0%	0.2%	0.1%	1.0%	-12.2
JCAHO Accredited	85.7%	82.5%	86.7%	86.3%	85.2%	1.4
Region						
Northeast	13.8%	19.2%	14.1%	15.2%	13.8%	-0.1
Midwest	16.6%	18.5%	18.5%	19.5%	15.8%	2.2
South	48.3%	52.8%	48.0%	45.9%	52.5%	-8.4
West	21.3%	9.5%	19.4%	19.3%	17.9%	8.7
Minority Serving Hospital	19.4%	13.1%	16.4%	16.6%	22.8%	-8.5
Hospital ADI						
Mean ± SD	52.8±22.5 (7861)	55.3±18.6 (1370)	52.6±20.7 (5181)	52.4±21.8 (4032)	53.3±21.1 (4568)	-1.9
Dual Enrollee	18.5%	15.5%	17.2%	18.2%	17.7%	1.9
Intubation	40.6%	37.1%	38.6%	39.4%	41.2%	-1.3
Vasopressor	9.0%	11.2%	11.2%	11.5%	12.7%	-11.9
RHC/PA Catheters	5.4%	6.1%	6.7%	7.4%	8.8%	-13.4
Other Chronic Conditions File Variables (40)						
ADHD and Other Conduct Disorders	0.9%	1.0%	1.0%	1.1%	1.2%	-2.8
Alcohol Use Disorders	5.3%	5.5%	5.2%	4.7%	5.1%	0.7
Anxiety Disorders Indicator	25.3%	22.4%	25.1%	25.1%	26.0%	-1.6
Autism Indicator	0.1%	0.1%	0.0%	0.0%	0.0%	2.5
Bipolar Disorder	3.8%	3.5%	4.1%	4.2%	4.5%	-3.5
Traumatic Brain Injury and Nonpsychotic Mental Disorders due to Brain Damage	1.0%	1.5%	1.1%	1.0%	1.2%	-2.2
Cerebral Palsy	0.3%	0.3%	0.3%	0.2%	0.2%	0.7

Subject Characteristic	Bottom fifth (7861 individuals)	Second fifth (1370 individuals)	Middle fifth (5181 individuals)	Fourth fifth (4032 individuals)	Top fifth (4568 individuals)	Standardized Difference (x100) Bottom fifth – top fifth
Cystic Fibrosis and Other Metabolic Developmental Disorders	2.0%	2.6%	1.8%	1.8%	2.4%	-3.0
Diagnosis and Procedure Basis for OUD	25.2%	23.2%	25.2%	25.2%	26.2%	-2.4
Drug Use Disorder	6.0%	5.6%	6.6%	6.3%	7.0%	-4.0
Epilepsy	3.2%	2.3%	3.1%	3.3%	3.4%	-1.0
Fibromyalgia, Chronic Pain and Fatigue	30.8%	29.9%	31.8%	32.7%	32.7%	-4.0
Sensory - Deafness and Hearing Impairment	12.2%	12.2%	12.6%	12.7%	11.9%	0.7
Viral Hepatitis (General)	2.3%	1.6%	2.7%	2.3%	2.4%	-0.7
HIV/AIDS	0.5%	0.3%	0.4%	0.4%	0.4%	2.4
Intellectual Disabilities and Related Conditions	0.6%	0.4%	0.6%	0.5%	0.5%	1.6
Learning Disabilities	0.2%	0.4%	0.3%	0.2%	0.3%	-2.4
Leukemias and Lymphomas	2.3%	2.0%	2.8%	2.5%	2.3%	-0.0
Liver Disease, Cirrhosis and Other Liver Conditions (excluding Hepatitis)	10.6%	10.3%	10.8%	10.6%	11.4%	-2.8
Migraine and other Chronic Headache	4.5%	4.3%	4.4%	5.6%	4.9%	-2.2
Mobility Impairments	7.0%	6.4%	6.5%	6.4%	7.3%	-1.2
Multiple Sclerosis and Transverse Myelitis	0.6%	0.9%	0.6%	0.7%	0.6%	0.3
Muscular Dystrophy	0.1%	0.1%	0.0%	0.0%	0.1%	0.8
Obesity	26.8%	25.0%	27.2%	26.0%	27.8%	-2.2
Other Developmental Delays	0.1%	0.0%	0.1%	0.1%	0.1%	0.8
Overarching OUD Disorder (Any of the Three Sub-Indicators)	3.2%	2.5%	3.8%	3.7%	4.0%	-4.6
Diagnosis and Procedure Basis for OUD	2.4%	1.9%	2.6%	2.8%	3.2%	-4.7
Opioid-Related Hospitalization or ED	2.2%	1.9%	2.7%	2.6%	2.5%	-1.8
Use of Medication-Assisted Treatment (MAT)	0.3%	0.2%	0.3%	0.2%	0.4%	-1.4
Personality Disorders	1.4%	1.5%	1.9%	2.0%	1.9%	-3.7
Post-Traumatic Stress Disorder	1.1%	1.6%	1.5%	1.5%	1.5%	-3.5
Peripheral Vascular Disease	31.9%	28.2%	30.5%	31.6%	32.7%	-1.9
Sickle Cell Disease	0.0%	0.1%	0.0%	0.0%	0.0%	0.9
Schizophrenia	1.3%	0.9%	1.3%	1.6%	1.5%	-1.2
Schizophrenia and Other Psychotic Disorders	4.4%	3.8%	4.4%	4.3%	4.1%	1.8
Spina Bifida and Other Congenital Anomalies of the Nervous System	0.2%	0.4%	0.1%	0.3%	0.2%	-1.4
Spinal Cord Injury	0.9%	1.6%	1.2%	1.6%	1.5%	-4.8
Tobacco Use Disorders	23.9%	26.4%	23.7%	23.9%	24.0%	-0.3
Pressure Ulcers and Chronic Ulcers	12.6%	11.2%	12.3%	13.5%	13.5%	-2.6

Subject Characteristic	Bottom fifth (7861 individuals)	Second fifth (1370 individuals)	Middle fifth (5181 individuals)	Fourth fifth (4032 individuals)	Top fifth (4568 individuals)	Standardized Difference (x100) Bottom fifth – top fifth
Sensory - Blindness and Visual Impairment	2.0%	1.6%	1.9%	2.1%	2.2%	-1.0
Percentage of Percutaneous Microaxial LVAD Use (%)	12.0%	12.1%	14.7%	21.1%	28.0%	-40.9

yrs, years; SD, standard deviation; AMI, acute myocardial infarction; STEMI, ST-elevation myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; RHC/PA, right heart /pulmonary artery catheter; ADI, area deprivation index; ADHD, attention deficit hyperactivity disorder; OUD, opioid use disorder.

eTable 6. Hospital Groups Defined by Tertiles of Change in Percutaneous Microaxial LVAD Use at the Hospital Level in the Year 2019 versus Year 2016.

Hospital Type	N	Number of Hospitals	Cutoff	Mean Change
Declining	2062	115	<0% (bottom third)	-8.92%
Moderately Increasing	2171	112	0% to 20% (middle third)	11.94%
Rapidly Increasing	2021	118	>20% (top third)	31.85%

eTable 7. Changes in Baseline Characteristics in Hospital Groups Defined by Tertiles of Change in Percutaneous Microaxial LVAD During Year 2019 Compared to the Year 2016

	Declining Hospitals			Moderately Increasing Hospitals			Rapidly Increasing Hospitals		
Subject Characteristic	**Year 2016 (957 individuals)**	**Year 2019 (1105 individuals)**	**Standardized Difference (x100)**	**Year 2016 (979 individuals)**	**Year 2019 (1192 individuals)**	**Standardized Difference (x100)**	**Year 2016 (948 individuals)**	**Year 2019 (1073 individuals)**	**Standardized Difference (x100)**
Demographics									
Age (yrs) Mean ± SD	73.1±9.9	73.0±10.2	0.7	74.4±10.1	74.6±9.4	-1.5	73.8±10.0	73.8±9.9	-0.1
Male	61.7%	58.5%	6.5	58.4%	61.2%	-5.6	62.7%	61.5%	2.4
Race									
White	86.8%	87.5%	-2.0	88.2%	89.5%	-4.3	87.8%	88.0%	-0.7
Black	8.2%	7.9%	1.0	5.9%	5.8%	0.6	6.1%	6.6%	-2.0
Other	5.0%	4.6%	1.9	5.9%	4.7%	5.5	6.1%	5.4%	3.1
Presenting AMI type									
STEMI	71.5%	69.0%	5.3	72.6%	72.0%	1.4	72.0%	68.3%	8.2
NSTEMI	28.5%	31.0%	-5.3	27.4%	28.0%	-1.4	28.0%	31.7%	-8.2
Cardiac Arrest on Presentation	14.1%	7.4%	21.7	13.0%	6.8%	20.8	14.2%	8.2%	19.2
Prior PCI	14.5%	14.4%	0.4	13.9%	13.6%	0.9	13.6%	15.2%	-4.5
Prior CABG	3.3%	3.8%	-2.5	3.2%	3.1%	0.4	2.4%	4.1%	-9.4
Chronic Conditions File Variables (27)									
Acute Myocardial Infarction	24.2%	23.2%	2.5	21.1%	21.7%	-1.4	21.1%	25.7%	-10.9
Alzheimer's Disease	3.3%	3.3%	-0.0	4.5%	3.8%	3.6	3.7%	3.0%	4.0
Alzheimer's Dsease and Rltd Disorders or Senile Dementia	12.5%	12.4%	0.4	13.3%	12.8%	1.6	12.1%	13.3%	-3.6
Atrial Fibrillation	15.3%	16.7%	-3.8	14.2%	14.4%	-0.7	15.0%	15.1%	-0.3
Cataract	56.7%	54.0%	5.5	56.5%	59.4%	-5.9	55.3%	58.2%	-6.0
Chronic Kidney Disease	44.1%	50.8%	-13.4	39.0%	48.7%	-19.7	40.6%	52.0%	-23.0
Chronic Obstructive Pulmonary Disease	33.0%	32.9%	0.4	32.6%	32.0%	1.3	30.4%	31.1%	-1.6
Heart Failure	50.3%	51.1%	-1.7	49.7%	50.8%	-2.0	47.8%	51.7%	-7.9
Diabetes	48.1%	49.2%	-2.3	42.3%	45.9%	-7.3	43.1%	46.9%	-7.5
Glaucoma	19.2%	18.7%	1.3	20.1%	20.3%	-0.4	20.6%	19.9%	1.8
Hip/Pelvic Fracture	3.6%	3.5%	0.1	4.0%	4.7%	-3.5	3.4%	3.1%	1.7
Ischemic Heart Disease	95.1%	94.9%	0.7	96.7%	95.6%	6.1	95.5%	96.1%	-3.1

	Declining Hospitals			Moderately Increasing Hospitals			Rapidly Increasing Hospitals		
Subject Characteristic	**Year 2016 (957 individuals)**	**Year 2019 (1105 individuals)**	**Standardized Difference (x100)**	**Year 2016 (979 individuals)**	**Year 2019 (1192 individuals)**	**Standardized Difference (x100)**	**Year 2016 (948 individuals)**	**Year 2019 (1073 individuals)**	**Standardized Difference (x100)**
Depression	32.9%	36.9%	-8.4	32.0%	29.9%	4.6	30.7%	32.5%	-3.9
Osteoporosis	14.7%	13.8%	2.8	19.7%	15.9%	9.9	14.0%	14.7%	-2.0
Rheumatoid Arthritis / Osteoarthritis	48.1%	54.0%	-11.9	54.2%	53.7%	1.1	47.3%	53.2%	-11.9
Stroke / Transient Ischemic Attack	20.6%	17.8%	7.0	17.0%	18.8%	-4.8	18.7%	17.7%	2.5
Breast Cancer	3.4%	3.3%	0.6	3.7%	3.5%	0.8	2.8%	3.5%	-3.9
Colorectal Cancer	2.5%	2.4%	0.4	1.7%	2.3%	-3.8	2.5%	3.1%	-3.3
Prostate Cancer	6.6%	6.9%	-1.2	6.1%	6.2%	-0.3	7.5%	5.7%	7.3
Lung Cancer	2.3%	2.1%	1.5	1.9%	2.5%	-3.9	3.0%	1.4%	10.7
Endometrial Cancer	0.5%	0.8%	-3.6	0.7%	0.8%	-0.5	0.4%	0.5%	-0.7
Anemia	53.6%	55.0%	-2.8	56.4%	52.4%	7.9	52.1%	55.4%	-6.5
Asthma	11.7%	13.9%	-6.7	13.2%	10.5%	8.3	11.5%	14.9%	-10.1
Hyperlipidemia	76.8%	77.5%	-1.6	78.2%	76.1%	5.1	76.1%	79.6%	-8.5
Benign Prostatic Hyperplasia	21.2%	21.5%	-0.8	22.5%	23.2%	-1.6	21.7%	22.4%	-1.5
Hypertension	82.0%	81.4%	1.7	82.9%	79.9%	7.9	78.5%	80.6%	-5.3
Acquired Hypothyroidism	21.9%	24.2%	-5.3	26.9%	24.5%	5.4	24.3%	25.4%	-2.7
Hospital Characteristics									
Hospital Size (Number of Beds) Mean ± SD	534.6±307.8	549.8±328.1	-4.8	523.2±346.7	527.3±386.9	-1.1	541.1±310.9	527.2±293.5	4.6
Ownership									
For Profit	12.6%	11.7%	3.0	8.7%	7.9%	2.9	11.1%	11.6%	-1.5
Private Nonprofit	75.0%	76.8%	-4.2	83.1%	85.6%	-6.7	79.1%	78.9%	0.4
Public	12.3%	11.5%	2.6	8.2%	6.5%	6.2	9.8%	9.5%	1.0
Teaching Status									
Metropolitan Teaching	78.7%	78.5%	0.5	73.7%	72.0%	4.0	80.1%	81.4%	-3.3
Metropolitan Non-teaching	21.3%	21.5%	-0.5	25.7%	27.0%	-2.9	19.9%	18.6%	3.3
Rural	0.0%	0.0%		0.5%	1.0%	-5.7	0.0%	0.0%	
JCAHO Accredited	85.3%	84.0%	3.6	89.1%	88.3%	2.3	83.4%	84.4%	-2.7
Region									
Northeast	10.0%	10.6%	-1.8	17.0%	17.3%	-0.9	14.7%	12.6%	6.1
Midwest	20.1%	18.8%	3.1	18.4%	15.9%	6.5	23.1%	21.6%	3.6
South	55.9%	55.6%	0.7	42.9%	42.6%	0.6	44.7%	49.7%	-9.9

	Declining Hospitals			Moderately Increasing Hospitals			Rapidly Increasing Hospitals		
Subject Characteristic	**Year 2016 (957 individuals)**	**Year 2019 (1105 individuals)**	**Standardized Difference (x100)**	**Year 2016 (979 individuals)**	**Year 2019 (1192 individuals)**	**Standardized Difference (x100)**	**Year 2016 (948 individuals)**	**Year 2019 (1073 individuals)**	**Standardized Difference (x100)**
West	14.0%	15.0%	-2.9	21.8%	24.2%	-5.7	17.5%	16.1%	3.7
Minority Serving Hospital	18.8%	21.0%	-5.5	13.1%	12.1%	3.0	19.5%	20.7%	-2.9
Hospital ADI									
Mean ± SD	56.5±18.7	56.5±19.0	-0.3	50.8±20.9	50.6±20.8	0.8	53.8±20.4	54.4±19.9	-2.8
Dual Enrollee	13.8%	19.5%	-15.3	16.9%	16.3%	1.6	19.1%	17.2%	4.8
Intubation	39.5%	34.3%	10.8	39.4%	38.5%	1.9	38.2%	42.1%	-8.0
Vasopressor	9.1%	14.8%	-17.8	7.6%	13.9%	-20.7	6.1%	14.2%	-26.9
RHC/PA Catheters	6.3%	6.5%	-1.0	6.7%	10.2%	-12.3	4.6%	9.0%	-17.5
Other Chronic Conditions File Variables (40)									
ADHD and Other Conduct Disorders	0.7%	1.7%	-9.0	0.5%	0.7%	-2.1	1.2%	1.1%	0.4
Alcohol Use Disorders	4.5%	5.3%	-3.9	4.9%	6.6%	-7.4	4.3%	4.7%	-1.6
Anxiety Disorders Indicator	23.4%	28.3%	-11.3	22.9%	24.1%	-2.8	24.4%	28.4%	-9.2
Autism Indicator	0.0%	0.0%		0.0%	0.2%	-5.8	0.1%	0.0%	4.6
Bipolar Disorder	4.9%	4.2%	3.6	2.9%	4.4%	-8.5	3.8%	4.2%	-2.0
Traumatic Brain Injury and Nonpsychotic Mental Disorders due to Brain Damage	1.6%	1.2%	3.4	1.0%	0.8%	1.9	1.2%	1.1%	0.4
Cerebral Palsy	0.1%	0.2%	-2.0	0.5%	0.2%	5.9	0.2%	0.4%	-3.0
Cystic Fibrosis and Other Metabolic Developmental Disorders	1.3%	1.8%	-4.5	1.1%	2.2%	-8.3	1.7%	2.5%	-5.8
Diagnosis and Procedure Basis for OUD	26.1%	29.2%	-6.9	25.4%	22.8%	6.1	23.8%	25.3%	-3.3
Drug Use Disorder	5.5%	7.6%	-8.3	5.1%	6.4%	-5.5	5.2%	8.9%	-14.5
Epilepsy	3.0%	3.3%	-1.3	3.1%	3.2%	-0.7	4.0%	3.3%	4.0
Fibromyalgia, Chronic Pain and Fatigue	26.2%	36.2%	-21.6	29.6%	35.4%	-12.4	27.3%	36.7%	-20.2

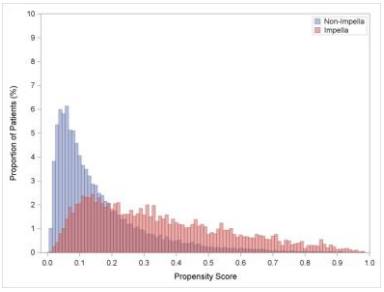
	Declining Hospitals			Moderately Increasing Hospitals			Rapidly Increasing Hospitals		
Subject Characteristic	**Year 2016 (957 individuals)**	**Year 2019 (1105 individuals)**	**Standardized Difference (x100)**	**Year 2016 (979 individuals)**	**Year 2019 (1192 individuals)**	**Standardized Difference (x100)**	**Year 2016 (948 individuals)**	**Year 2019 (1073 individuals)**	**Standardized Difference (x100)**
Sensory - Deafness and Hearing Impairment	11.9%	12.7%	-2.3	11.7%	13.4%	-5.1	11.2%	11.9%	-2.3
Viral Hepatitis (General)	2.1%	3.5%	-8.7	1.8%	2.8%	-6.2	2.2%	1.6%	4.6
HIV/AIDS	0.4%	0.5%	-1.8	0.2%	0.5%	-5.0	0.3%	0.6%	-3.7
Intellectual Disabilities and Related Conditions	0.3%	0.5%	-3.5	0.5%	0.5%	0.1	0.4%	0.7%	-3.2
Learning Disabilities	0.2%	0.1%	3.1	0.0%	0.1%	-4.1	0.0%	0.7%	-11.5
Leukemias and Lymphomas	1.9%	3.1%	-7.7	2.1%	2.2%	-0.2	1.8%	2.4%	-4.4
Liver Disease, Cirrhosis and Other Liver Conditions (excluding Hepatitis)	10.8%	11.5%	-2.3	7.7%	11.0%	-11.5	10.1%	10.5%	-1.3
Migraine and other Chronic Headache	4.2%	5.9%	-7.8	4.0%	6.0%	-9.1	4.0%	5.0%	-4.9
Mobility Impairments	6.9%	6.9%	0.1	6.5%	6.8%	-1.0	5.7%	7.7%	-8.2
Multiple Sclerosis and Transverse Myelitis	0.4%	0.5%	-0.5	0.7%	0.2%	8.3	0.1%	0.3%	-4.0
Muscular Dystrophy	0.1%	0.1%	0.4	0.0%	0.0%		0.1%	0.0%	4.6
Obesity	25.4%	31.1%	-12.8	19.2%	29.2%	-23.5	21.9%	30.0%	-18.5
Other Developmental Delays	0.0%	0.0%		0.1%	0.1%	0.6	0.1%	0.1%	0.4
Overarching OUD Disorder (Any of the Three Sub-Indicators)	3.2%	4.1%	-4.4	2.7%	3.5%	-5.0	2.4%	5.7%	-16.6
Diagnosis and Procedure Basis for OUD	2.6%	3.0%	-2.3	1.8%	2.3%	-3.0	1.9%	4.6%	-15.1
Opioid-Related Hospitalization or ED	1.9%	3.0%	-7.2	2.3%	2.5%	-1.1	1.6%	2.9%	-8.8
Use of Medication-Assisted Treatment (MAT)	0.3%	0.2%	2.7	0.2%	0.3%	-1.0	0.0%	0.5%	-9.7
Personality Disorders	0.9%	3.1%	-15.3	1.3%	1.6%	-2.2	1.3%	1.9%	-4.8

	Declining Hospitals			Moderately Increasing Hospitals			Rapidly Increasing Hospitals		
Subject Characteristic	**Year 2016 (957 individuals)**	**Year 2019 (1105 individuals)**	**Standardized Difference (x100)**	**Year 2016 (979 individuals)**	**Year 2019 (1192 individuals)**	**Standardized Difference (x100)**	**Year 2016 (948 individuals)**	**Year 2019 (1073 individuals)**	**Standardized Difference (x100)**
Post-Traumatic Stress Disorder	1.6%	2.2%	-4.5	1.0%	1.0%	0.1	0.8%	2.0%	-9.5
Peripheral Vascular Disease	28.7%	32.5%	-8.1	29.7%	29.4%	0.8	29.5%	33.0%	-7.5
Sickle Cell Disease	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Schizophrenia	1.0%	2.1%	-8.4	1.2%	1.0%	2.1	1.4%	1.3%	0.6
Schizophrenia and Other Psychotic Disorders	5.1%	4.3%	3.7	5.3%	4.4%	4.0	4.5%	4.6%	-0.1
Spina Bifida and Other Congenital Anomalies of the Nervous System	0.0%	0.2%	-6.0	0.0%	0.2%	-5.8	0.3%	0.1%	4.9
Spinal Cord Injury	0.9%	1.6%	-6.1	0.7%	1.7%	-8.9	0.7%	1.4%	-6.4
Tobacco Use Disorders	24.0%	26.9%	-6.5	23.3%	25.6%	-5.3	22.0%	24.8%	-6.5
Pressure Ulcers and Chronic Ulcers	12.6%	15.1%	-7.1	11.5%	11.8%	-0.9	10.8%	13.0%	-7.1
Sensory - Blindness and Visual Impairment	1.7%	2.4%	-4.9	1.3%	0.9%	3.8	2.8%	1.7%	7.9

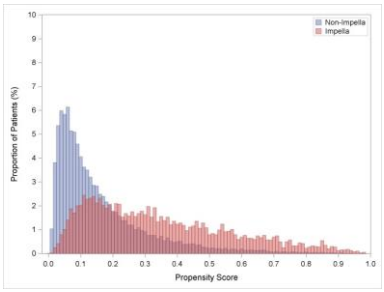
yrs, years; SD, standard deviation; AMI, acute myocardial infarction; STEMI, ST-elevation myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; RHC/PA, right heart catheter/pulmonary artery catheter; ADI, area deprivation index; ADHD, attention deficit hyperactivity disorder; OUD, opioid use disorder.

eFigure 1A-C. Histogram of Predicted Probability of Receiving Percutaneous Microaxial LVAD Calculated from: A) Primary model B) Sensitivity Model 1 C) Sensitivity Model 2.

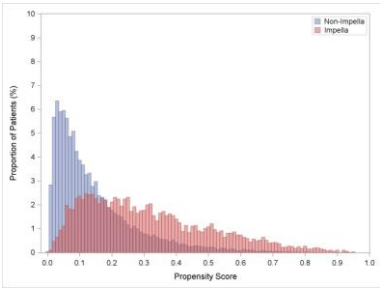
A)



B)

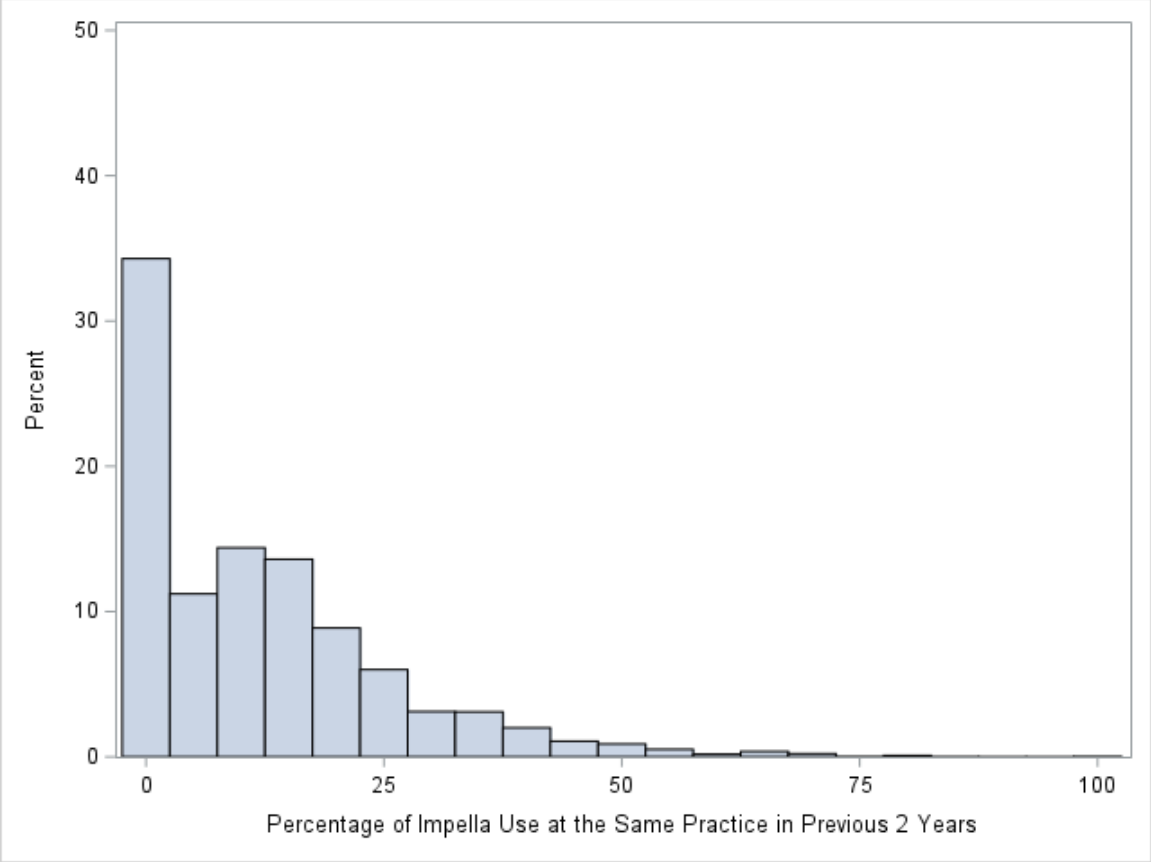


C)

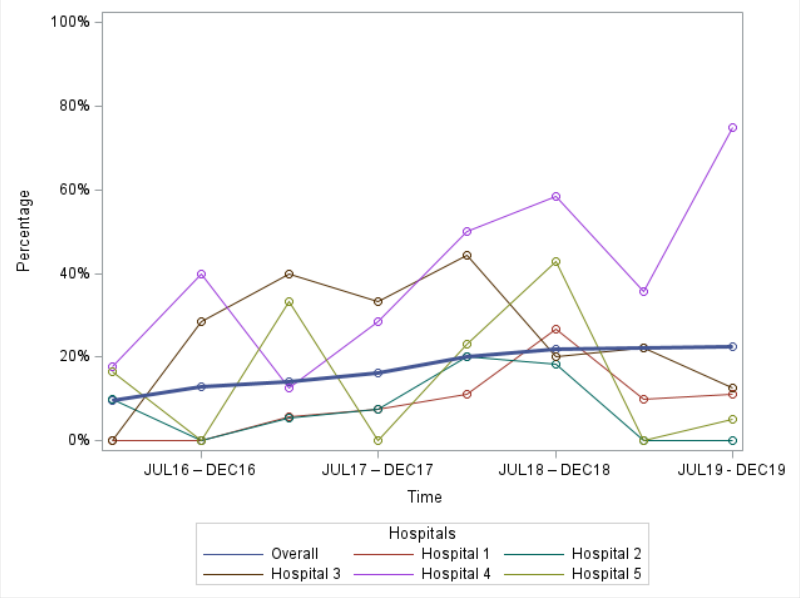


- *Primary model propensity scores were calculated from a hierarchical logistic regression with hospital ID included as random intercept.*
- *Sensitivity model 1 propensity scores were calculated from a hierarchical logistic regression with hospital ID included as a random intercept and hospital size included as a fixed effect.*
- *Sensitivity model 2 propensity scores were calculated from a logistic regression with hospital ID included as a fixed effect.*

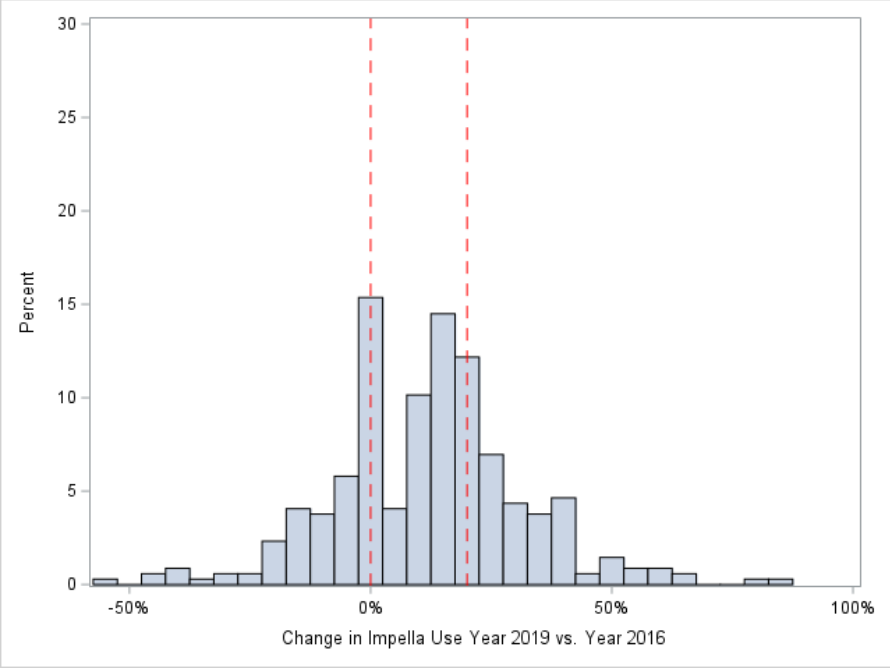
eFigure 2. Histogram of the Proportion of Patients Presenting with AMICS Undergoing Percutaneous Coronary Intervention Receiving Percutaneous Microaxial LVAD in the Previous Two Years Before the Index Procedure at Each Hospital



eFigure 3. Temporal Trends in Use of Percutaneous Microaxial LVAD as a Percentage of Admissions for AMICS undergoing Percutaneous Coronary Intervention (Overall and at the 5 Highest Volume Centers).

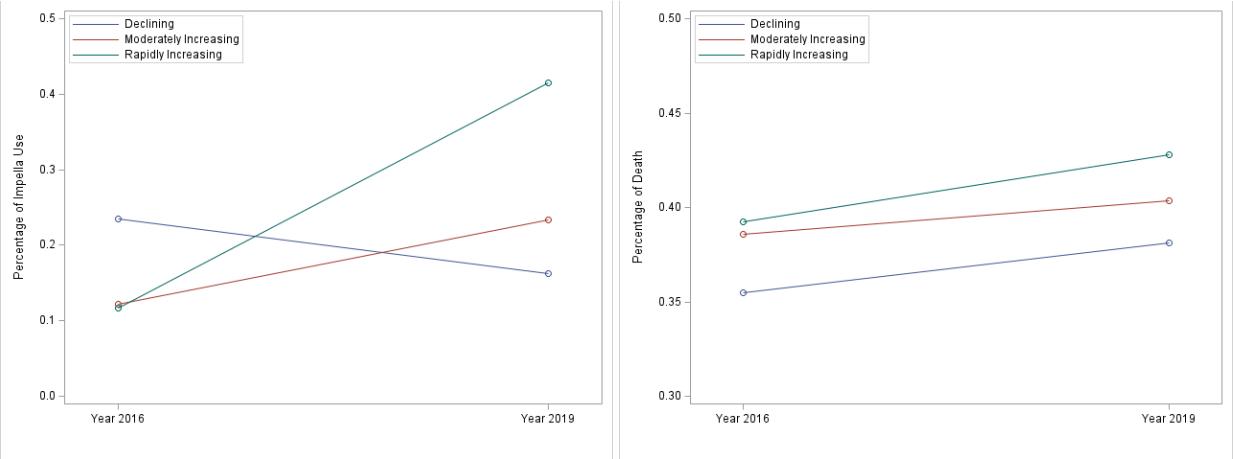


eFigure 4. Histogram of Change in Percutaneous Microaxial LVAD Use by Hospital in the Year 2019 versus Year 2016.



eFigure 5. Difference-in-Differences Among Patients in Hospitals with Declining, Moderately Increasing, and Rapidly Increasing Percutaneous Microaxial LVAD use for A) Percentage of Percutaneous Microaxial LVAD use and B) 30-day Mortality.

A) **B)**



eReferences

1. Services CfMM. Chronic Conditions Data Warehouse. https://www2.ccwdata.org/web/guest. Accessed 1/12/2020, 2020.

2. Lasser KE, Hanchate AD, McCormick D, Chu C, Xuan Z, Kressin NR. Massachusetts Health Reform's Effect on Hospitals' Racial Mix of Patients and on Patients' Use of Safety-net Hospitals. *Med Care.* 2016;54(9):827-836.

3. Thiele H, Zeymer U, Neumann FJ, et al. Intraaortic balloon support for myocardial infarction with cardiogenic shock. *N Engl J Med.* 2012;367(14):1287-1296.

4. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika.* 1983;70(1):41-55.

5. Imbens GW, Angrist JD. Identification and estimation of local average treatment effects. *Econometrica: journal of the Econometric Society.* 1994:467-475.

6. Orellana L, Rotnitzky A, Robins JM. Dynamic regime marginal structural mean models for estimation of optimal dynamic treatment regimes, Part I: main content. *Int J Biostat.* 2010;6(2):Article 8.

7. Orellana L, Rotnitzky A, Robins JM. Dynamic regime marginal structural mean models for estimation of optimal dynamic treatment regimes, Part II: proofs of results. *Int J Biostat.* 2010;6(2):Article 9.

8. Petito LC, García-Albéniz X, Logan RW, et al. Estimates of overall survival in patients with cancer receiving different treatment regimens: emulating hypothetical target trials in the surveillance, epidemiology, and end results (SEER)–Medicare linked database. *JAMA network open.* 2020;3(3):e200452-e200452.