Supplemental Material for Association of Center Volume And In-Hospital Mortality in Heart Failure Hospitalizations

Supplementary Appendix

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Statewide Planning and Research Cooperative System (SPARCS)

The Statewide Planning and Research Cooperative System (SPARCS), established by New York State Department of Health (NYSDOH), is a comprehensive data reporting system from non-federal acute care hospitals in the NY State. It collects patient level details on patient characteristics, diagnoses, treatments and services for both inpatient and outpatient hospital services, including ED visits and ambulatory surgery centers.

Facilities submit their SPARCS data on a monthly basis, and are required to submit 95% of the data within 60 days and 100% of the data within 180 days following the end of the month of patient discharge or visit. SPARCS data are edited monthly to identify errors and audit reports are generated monthly following updates. The quality and completeness of data reported by each facility is regularly reviewed by SPARCS Operations staff to ensure data quality standards. The SPARCS data is also verified at regular intervals with other data sources (Medicaid, New York State Vital Statistics Data and Intuitional Cost Reports) to ensure consistency.

The SPARCS provides de-identified yearly hospital inpatient discharge files available for public use. This de-identified data does not contain protected health information (PHI) under Health Insurance Portability and Accountability Act (HIPAA). The health information is not individually identifiable and all data elements considered identifiable are redacted[1].

Clinical Classification Software (CCS)

Clinical Classification Software (CCS) for ICD-9-CM is a based on *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM). The Agency for Healthcare Research and Quality (AHRQ) developed CCS tool under Healthcare Cost and Utilization Project (HCUP) for clustering the ICD-9-CM's over 14,000 diagnosis codes and 3,900 procedure codes into a smaller number of clinically meaningful categories. CCS tool allows clinical grouping of diagnosis for the purposes of research and health care utilization and cost analytics[2].

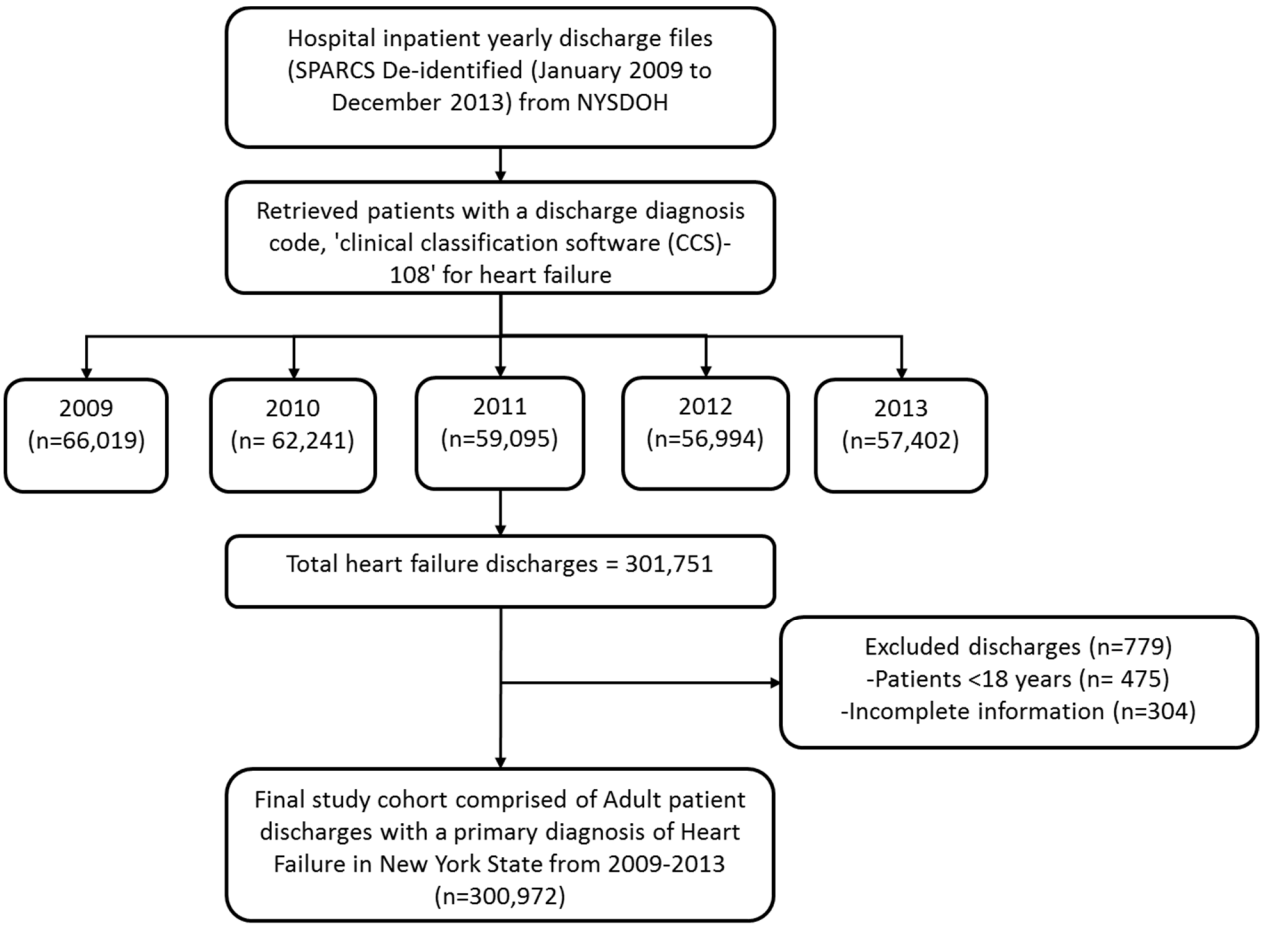
All Patient Refined- Diagnosis Related Groups (APR-DRGs)

The Diagnosis Related Groups (DRGs) were a patient classification scheme initially developed to analyze the type of patients (case mix index) treated across various hospitals and the costs incurred. The 3M™ All Patient Refined DRG (APR DRG) Classification System was developed to adjust inpatient claims data for severity of illness (SOI) and risk of mortality (ROM). Public and commercial organizations use the 3M APR DRG methodology for payment or public quality reporting[3].

The APR-DRGs expand the basic DRG structure by adding four subclasses to each DRG. The addition of the four subclasses addresses patient differences relating to severity of illness and risk of mortality. The four severity of illness subclasses and the four risk of mortality subclasses are numbered sequentially from 1 to 4 indicating

minor, moderate, major, or extreme severity of illness (SOI) or risk of mortality (ROM) respectively. The main principle of APR-DRGs is that the severity of illness and the risk of mortality subclass of each patient is dependent on the patient's underlying diagnosis. The SOI and the ROM also increases with the increase in the number of co-morbidities of a patient. The addition of SOI and ROM provide an accurate evaluation of both resource use and outcomes[4].

Supplement-Figure 1: Flow chart for study cohort derivation



Supplementary-Table A: Multivariate model for factors associated with in-hospital mortality **(n=300,972)**

	HR (95% CI limits)	p value
Age (70 years or above)	2.294(2.184-2.411)	< 0.001
Race (Black vs rest)	0.675(0.639-0.713)	< 0.001
Ethnicity (Hispanic vs rest)	0.835(0.782-0.893)	< 0.001
APR severity of illness (major/extreme)	1.257(1.179-1.340)	< 0.001
APR risk for mortality (major/extreme)	3.156(2.953-3.374)	< 0.001
Admission through the emergency department	0.706(0.677-0.736)	< 0.001
Center volume (measured in thousands)	0.877(0.868-0.885)	< 0.001

Table showing multivariate Cox HR model using a backward stepwise selection method for factors associated with in-hospital mortality, corresponding hazard ratios (HR), 95% confidence interval (CI) and p values

Supplementary-Table B: Crude mortality rates in different Center Volume groups by APR-SOI and APR-ROM

Center Volume Groups	Both APR-SOI and APR-ROM (minor to moderate) (n=121,676)	Relative Risk Reduction	APR-SOI (major to extreme) but APR-ROM (minor to moderate) (n=41,761)	Relative Risk Reduction	APR-SOI (minor to moderate) but APR-ROM (major to extreme) (n=17,482)	Relative Risk Reduction	Both APR-SOI and APR-ROM (major to extreme) (n=120,053)	Relative Risk Reduction
Low	1.34% [3(2-5)]	Reference	1.41%[5(3-7)]	Reference	4.25%[4(3-6)]	Reference	9.86%[6(4-10)]	Reference
Medium	0.95%[3(2-5)]	29.1%*	0.58% [5(3-7)]	58.8%*	1.95%[4(3-6)]	54.1%*	8.37%[7(4-11)]	15.1%*
High	0.53%[3(2-5)]	60.4%*	0.36%[5(2-7)]	74.4%*	1.56%[4(3-6)]	63.3%*	8.37%[7(4-12)]	15.1%*

Crude in-hospital mortality rates% with length of hospital stay in days [median (Q1-Q3)], in the three center volume groups by different APR-SOI and APR-ROM categories. Also presented are relative risk reduction (RRR) % in various subgroups, compared to low volume centers. *all p<0.001.

1. Bureau of Health Informatics OoQaPS, NY State Department of Health SPARCS Operations Guide 2014:1-31.
2. HCUP-CCS. Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. Secondary Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality June 2015. www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp.
3. 3M. 3M APR DRG. Secondary 3M APR DRG 2017. http://www.3m.com/3M/en_US/company-us/all-3m-products/~/3M-APR-DRG-Software?N=5002385+8707795+8709364+8711017+8717532+8717554+3293081278&rt=rud.
4. Averill RF, Goldfield N, Steinbeck B, et al. All patient refined diagnosis related groups (APR-DRGs). Version 2003;**15**:98-054