

## Supplementary Appendix

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

Supplement to: Ross JS, Normand S-LT, Wang Y, et al. Hospital volume and 30-day mortality for three common medical conditions. *N Engl J Med* 2010;362:1110-8.

**Online Supplement Table 1:** International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnostic codes used to identify patients who were hospitalized for acute myocardial infarction, heart failure, and pneumonia.

Acute Myocardial Infarction		Heart Failure		Pneumonia	
ICD-9-CM	Description	ICD-9-CM	Description	ICD-9-CM	Description
410.00	Acute Myocardial Infarction (anterolateral wall) – episode of care unspecified	402.01	Malignant hypertensive heart disease with heart failure	480.3	Pneumonia due to Severe Acute Respiratory Syndrome (SARS)-associated coronavirus
410.01	Acute Myocardial Infarction (anterolateral wall) – initial episode of care	402.11	Benign hypertensive heart disease with heart failure	480.8	Viral pneumonia: pneumonia due to other virus not elsewhere classified
410.10	Acute Myocardial Infarction (other anterior wall) – episode of care unspecified	402.91	Hypertensive heart disease with heart failure	480.9	Viral pneumonia: viral pneumonia, unspecified
410.11	Acute Myocardial Infarction (other anterior wall) – initial episode of care	404.01	Malignant hypertensive heart and renal disease with heart failure	481	Pneumococcal pneumonia (Streptococcus pneumoniae pneumonia)
410.20	Acute Myocardial Infarction	404.03	Malignant hypertensive heart	482.0	Other bacterial pneumonia:

	(inferolateral wall) – episode of care unspecified		and renal disease with heart failure and renal failure		pneumonia due to Klebsiella pneumoniae
410.21	Acute Myocardial Infarction (inferolateral wall) – initial episode of care	404.11	Benign hypertensive heart and renal disease with heart failure	482.1	Other bacterial pneumonia: pneumonia due to Pseudomonas
410.30	Acute Myocardial Infarction (inferoposterior wall) – episode of care unspecified	404.13	Benign hypertensive heart and renal disease with heart failure and renal failure	482.2	Other bacterial pneumonia: pneumonia due to Hemophilus influenzae (H. influenzae)
410.31	Acute Myocardial Infarction (inferoposterior wall) – initial episode of care	404.91	Hypertensive heart and renal disease with heart failure	482.30	Pneumonia due to Streptococcus: Streptococcus, unspecified
410.40	Acute Myocardial Infarction (other inferior wall) – episode of care unspecified	404.93	Hypertensive heart and renal disease with heart failure and renal failure	482.31	Pneumonia due to Streptococcus: Group A
410.41	Acute Myocardial Infarction (other inferior wall) – initial episode of care	428.0	Congestive heart failure	482.32	Pneumonia due to Streptococcus: Group B

410.50	Acute Myocardial Infarction (other lateral wall) – episode of care unspecified	428.1	Left heart failure	482.39	Pneumonia due to Streptococcus: Other Streptococcus
410.51	Acute Myocardial Infarction (other lateral wall) – initial episode of care	428.9	Heart failure, unspecified	482.41	Pneumonia due to Staphylococcus: Pneumonia due to Staphylococcus, unspecified
410.60	Acute Myocardial Infarction (true posterior wall) – episode of care unspecified			482.42	Pneumonia due to Staphylococcus: Pneumonia due to Staphylococcus aureus
410.61	Acute Myocardial Infarction (true posterior wall) – initial episode of care			482.49	Pneumonia due to Staphylococcus: Other Staphylococcus pneumonia
410.70	Acute Myocardial Infarction (subendocardial) – episode of care unspecified			482.81	Pneumonia due to other specified bacteria: Anaerobes
410.71	Acute Myocardial Infarction (subendocardial) –			482.82	Pneumonia due to other specified bacteria:

	initial episode of care				Escherichia coli (E. coli)
410.80	Acute Myocardial Infarction (other specified site) – episode of care unspecified			482.83	Pneumonia due to other specified bacteria: Other gram-negative bacteria
410.81	Acute Myocardial Infarction (other specified site) – initial episode of care			482.84	Pneumonia due to other specified bacteria: Legionnaires' disease
410.90	Acute Myocardial Infarction (unspecified site) – episode of care unspecified			482.89	Pneumonia due to other specified bacteria: Other specified bacteria
410.91	Acute Myocardial Infarction (unspecified site) – initial episode of care			482.9	Other bacterial pneumonia: Bacterial pneumonia unspecified
				483.0	Pneumonia due to other specified organism: Mycoplasma pneumoniae
				483.1	Pneumonia due to

					other specified organism: Chlamydia
				483.8	Pneumonia due to other specified organism: Other specified organism
				485	Bronchopneumonia, organism unspecified
				486	Pneumonia, organism unspecified
				487.0	Influenza with pneumonia

**Online Supplement Table 2:** Patient demographic characteristics, cardiovascular past medical history, and co-morbid conditions for fee-for-service Medicare beneficiaries admitted for acute myocardial infarction, heart failure, and pneumonia from 2004-2006, stratified by hospital condition-specific volume category.

	Acute Myocardial Infarction				Heart Failure				Pneumonia			
	Total Sample	Hospital Volume			Total Sample	Hospital Volume			Total Sample	Hospital Volume		
		Small	Medium	Large		Small	Medium	Large		Small	Medium	Large
<b>Total No. of Patients</b>	734972	74893	159104	500975	1324287	177882	319360	827045	1418252	252113	367348	798791
<b>(%)</b>	(100)	(10.2)	(21.7)	(68.2)	(100)	(13.4)	(24.1)	(62.5)	(100)	(17.8)	(25.9)	(56.3)
<b>Demographics</b>												
Age: mean (SD)	79.1 (7.9)	81.5 (8.2)	79.8 (8.0)	78.5 (7.8)	80.5 (7.9)	81.6 (8.0)	80.6 (7.9)	80.2 (7.8)	80.2 (8.0)	80.8 (8.2)	80.1 (8.0)	80.1 (7.9)
Female, %	51.2	56.6	53.5	49.7	50.8	60.5	59.2	57.0	55.9	55.6	56.2	55.9
<b>Cardiovascular Past Medical History,* %</b>												
History of PCI	4.7	2.9	4.2	5.2	6.7	4.5	5.9	7.4	3.3	2.5	2.9	3.7
History of CABG Surgery*	6.5	7.0	7.4	6.2	11.8	8.4	11.0	12.8	5.4	4.1	5.2	5.9
Heart Failure	30.3	38.2	33.9	27.9	73.1	72.1	72.4	73.6	39.1	38.7	38.7	39.5
Myocardial Infarction	15.2	16.2	15.7	14.9	9.6	8.1	9.4	9.9	3.7	3.2	3.6	3.9
Anterior MI	11.2	10.3	10.2	11.6	--	--	--	--	--	--	--	--

Inferior/Lateral/ Posterior MI	14.6	11.6	12.5	15.7	--	--	--	--	--	--	--	--
Unstable Angina	11.6	11.0	11.9	11.6	15.2	11.9	14.5	16.1	7.2	5.9	7.0	7.8
Chronic Atherosclerosis	73.5	58.0	68.0	77.5	71.0	63.3	69.2	73.4	46.7	42.2	45.8	48.6
Cardiopulmonary- Respiratory Failure and Shock	7.3	7.5	8.3	7.0	17.5	14.7	17.1	18.3	14.4	11.8	14.1	15.4
Valvular Heart Disease	18.5	18.1	20.1	18.1	47.0	36.8	45.1	11.0	--	--	--	--
<b><i>Co-morbid Condition,* %</i></b>												
Hypertension	59.2	57.7	59.3	59.4	82.8	81.7	82.5	83.1	75.4	73.1	75.2	76.1
Stroke	7.0	8.4	7.9	6.5	10.6	9.3	10.3	11.0	10.9	9.7	11.0	11.3
Cerebrovascular Disease	12.6	13.4	13.0	12.3	--	--	--	--	19.7	17.8	19.3	20.4
Renal Failure	13.2	13.8	14.4	12.7	28.0	22.7	26.5	29.8	14.3	11.5	13.7	15.4
COPD	28.8	30.8	30.4	28.1	47.0	46.0	47.7	46.9	56.1	53.3	56.5	56.8
Pneumonia	12.7	17.0	14.3	11.6	38.5	40.0	38.9	38.0	41.9	40.3	41.8	42.5
Diabetes	39.5	40.9	41.0	38.8	48.7	46.4	48.5	49.2	--	--	--	--

Protein-Calorie Malnutrition	3.5	3.8	3.8	3.3	5.2	4.3	5.1	5.6	8.2	6.4	8.2	8.7
Dementia	14.5	20.9	17.0	12.8	20.2	21.1	20.6	19.9	27.6	27.1	28.0	27.5
Functional Disability	4.8	6.0	5.4	4.4	6.8	6.6	6.8	6.9	7.6	7.3	7.8	7.6
Peripheral Vascular Disease	20.6	20.1	21.9	20.3	32.1	26.4	30.3	34.0	26.0	22.1	25.2	27.6
Metastatic Cancer	3.5	3.5	3.7	3.5	4.0	3.3	3.8	4.3	7.9	6.1	7.5	8.7
Trauma in Last Year	22.3	25.9	24.1	21.2	34.1	34.9	34.4	33.8	34.7	34.5	34.6	34.8
Major Psychiatric Disorders	5.5	7.2	6.3	5.0	8.6	9.1	8.6	8.5	11.3	11.1	11.3	11.3
Chronic Liver Disease	0.9	0.8	1.0	0.9	1.9	1.5	1.9	2.0	1.4	1.1	1.4	1.5
Severe Hematological Disorder	--	--	--	--	--	--	--	--	3.5	2.5	3.3	3.9
Iron Deficiency	--	--	--	--	--	--	--	--	43.6	41.1	43.1	44.5
Depression	--	--	--	--	--	--	--	--	15.8	16.2	15.8	15.7
Parkinson's or Huntington's Disease	--	--	--	--	--	--	--	--	4.3	4.3	4.3	4.2
Seizure Disorders or	--	--	--	--	--	--	--	--	5.8	5.1	5.8	6.0

Convulsions												
Fibrosis of Lung or Other Chronic Lung Disorders	--	--	--	--	--	--	--	--	16.7	13.4	16.5	17.8
Asthma	--	--	--	--	--	--	--	--	11.3	10.6	11.3	11.5
Vertebral Fractures	--	--	--	--	--	--	--	--	4.9	4.5	4.8	5.0

Notes: AMI = Acute Myocardial Infarction; PCI = Percutaneous Coronary Intervention; CABG = Coronary Artery Bypass Graft; COPD = Chronic Obstructive

Pulmonary Disease; -- = clinical characteristic not used for risk-standardization for that condition-specific hospitalization. Risk-adjustment models included age, sex, and the same clinical characteristic variables used for the risk-standardization measures developed for each condition independently for the Centers for Medicare & Medicaid Services and endorsed by the National Quality Forum (NQF) for hospital performance evaluation.<sup>11, 12</sup> The AMI model includes 10 cardiovascular clinical characteristics and 15 other co-morbid conditions, the HF model includes 8 and 14, and the pneumonia model includes 7 and 22.

\* Cardiovascular past medical history and co-morbid conditions were based on hierarchical condition categories, with the exception of history of PTCA and CABG surgery and anterior and inferior/lateral/posterior MI.