

Supplementary Online Content

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

eTable 1: International Classification of Disease, Ninth Revision, Clinical Modification Codes Used to Define Heart Failure, Acute Myocardial Infarction, and Pneumonia Cohorts.

Cohort name	Constituent ICD-9-CM codes
Heart failure	402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.xx
Acute myocardial infarction	410.xx excluding those with 410.x2 (AMI, subsequent episode of care)
Pneumonia	480.x, 481, 482.xx, 483.x, 485, 486, 487.0, and 488.11

ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification

eTable 2: Modified Condition Category Constituents.

Modified condition category number and name	Constituent CMS condition category codes	Additional ICD-9-CM diagnostic codes
1 - Heart failure	80	
2 - Acute myocardial infarction	81	
3 - Unstable angina and other acute ischemic heart disease	82	
4 - Chronic angina and coronary artery disease	83, 84	
5 - Valvular/rheumatic heart disease	86	
6 - Other cardiac disease including congenital heart and hypertensive disease	85, 87, 88, 94, 89, 90, 91	
7 - Arrhythmias and conduction disorders	92, 93	
8 - Pleural effusion/pneumothorax	114	
9 - Chest pain	N/a (constituent ICD-9-CM codes on right)	788.50, 788.59
10 - Syncope	N/a (constituent ICD-9-CM codes on right)	780.2
11 - Acute stroke/transient ischemic attack	95, 96, 97	
12 - Pulmonary embolism/deep venous thrombosis	N/a (constituent ICD-9-CM codes on right)	415.1, 415.11, 415.19, 453.4, 453.40, 453.41, 453.42, 453.8, 453.81, 453.82, 453.83, 453.84, 453.85, 453.86, 453.87, 453.89, 453.9
13 - Other peripheral vascular disease	104, 105, 106 (excluded ICD-9-CM codes on right)	Exclude 415.1, 415.11, 415.19, 453.4, 453.40, 453.41, 453.42, 453.8, 453.81, 453.82, 453.83, 453.84, 453.85, 453.86, 453.87, 453.89, 453.9
14 - Cardio-respiratory failure	77, 78, 79	
15 - Chronic obstructive pulmonary disease/asthma	108, 110	
16 - Pneumonia including aspiration pneumonitis	111, 112, 113	
17 - Septicemia/shock	2	
18 - Urinary tract infection and urinary system complaints	135	
19 - Cellulitis	152	
20 - Clostridium difficile-associated infection	N/a (constituent ICD-9-CM codes on right)	8.45
21 - Renal disorders including renal failure and fluid, electrolyte, and acid-base abnormalities	131, 23	
22 - Anemia	47	
23 - Gastrointestinal hemorrhage	N/a (constituent ICD-9-CM codes on right)	531.0, 531.00, 531.01, 531.2, 531.20, 531.21, 531.40, 531.41, 531.6, 531.60, 531.61, 532.0, 532.00, 532.01, 532.2, 532.20, 532.21, 532.4, 532.40, 532.41, 532.6, 532.60, 532.61, 533.0, 533.00, 533.01, 533.2, 533.20, 533.21, 533.4, 533.40, 533.41, 533.6, 533.60, 533.61, 534.0, 534.00, 534.01, 534.2, 534.20, 534.21, 534.4, 534.40, 534.41, 534.6, 534.60, 534.61, 535.01, 535.11, 535.41, 535.51, 535.61, 562.02, 562.12, 569.3, 578, 578.0, 578.1, 578.9
24 - Diabetes and its complications	15, 16, 17, 18, 19, 20	
25 - Fibrosis of lung and other chronic lung disorders	109	
26 - Hip fracture	158	
27 - Complications of care	163, 164, 165	
28 - Other lung disorders including acute, congenital, and unspecified lung abnormalities	115 (additional ICD-9-CM codes on right)	788.0, 788.00, 788.01, 788.02, 788.05, 788.06, 788.9
29 - Primary cancer of the trachea, bronchus, lung, and pleura	N/a (constituent ICD-9-CM codes on right)	162.9, 162.3, 162.5, 162.9, 162.2, 162.4
30 - Other admitting diagnoses	See below	See below

Constituents of modified condition category 30 - other admitting diagnoses	1, 3, 4, 5, 6	
Other infections	7, 8, 9, 10, 11, 12, 13, 14	
Cancer	21, 22, 24	
Endocrine/metabolic	25, 26, 27, 28, 29	
Liver disease	30, 31, 32, 33, 34, 35, 36 (Excluded ICD-9- CM codes on right)	Exclude 531.0, 531.00, 531.01, 531.2, 531.20, 531.21, 531.40, 531.41, 531.6, 531.60, 531.61, 532.0, 532.00, 532.01, 532.2, 532.20, 532.21, 532.4, 532.40, 532.41, 532.6, 532.60, 532.61, 533.0, 533.00, 533.01, 533.2, 533.20, 533.21, 533.4, 533.40, 533.41, 533.6, 533.60, 533.61, 534.0, 534.00, 534.01, 534.2, 534.20, 534.21, 534.4, 534.40, 534.41, 534.6, 534.60, 534.61, 535.01, 535.11, 535.41, 535.51, 535.61, 562.02, 562.12, 569.3, 578, 578.0, 578.1, 578.9
Digestive (Gastrointestinal)		
Musculoskeletal	37, 38, 39, 40, 41, 42, 43	
Other hematologic	44, 45, 46	
Cognitive	48, 49, 50	
Substance abuse	51, 52, 53	
Psychiatric	54, 55, 56, 57, 58, 59, 60	
Development disorders	61, 62, 63, 64, 65, 66	
Spinal cord	67, 68, 69	
Neuromuscular	70, 71, 72, 73, 74, 75, 76	
Non-acute cerebrovascular disease	98, 99, 100, 101, 102, 103	
Other pulmonary	107	
Ophthalmologic	116, 117, 118, 119, 120, 121, 122, 123, 124	
Ear, nose, and throat	125, 126, 127	
Other renal	128, 129, 130, 132	
Genitourinary	133, 134, 136, 137, 138, 139, 140	
Obstetric	141, 142, 143, 144, 145, 146, 147	
Other dermatologic	150, 151, 153	
Injury excluding hip fracture	154, 155, 156, 157, 159, 160, 161, 162 (Excluded ICD-9-CM codes on right)	Exclude 162.9, 162.3, 162.5, 162.8, 162.2, 162.4
Symptoms (major and minor) excluding respiratory	166, 167 (Excluded ICD-9-CM codes on right)	Exclude 780.2, 786.0, 786.00, 786.01, 786.02, 786.05, 786.06, 786.50, 786.59, 786.9, 780.2
Neonatal	168, 169, 170, 171, 172	
Organ transplant	173, 174, 175	
Miscellaneous surgical and non-surgical procedures	176, 177, 178, 179, 180, 181, 182	
Durable medical equipment	185, 186, 187, 188, 189	
Other	183, 184	
Skin ulcer including decubitus ulcer	148, 149	
Complications of care	163, 164, 165	

CMS: Centers for Medicare & Medicaid Services; ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification

eTable 3: Modified Condition Categories for Cardiovascular Diagnoses.

Modified condition category codes for cardiovascular diagnoses

- 1 - Heart failure
 - 2 - Acute myocardial infarction
 - 3 - Unstable angina and other acute ischemic heart disease
 - 4 - Chronic angina and coronary artery disease
 - 5 - Valvular/rheumatic heart disease
 - 6 - Other cardiac disease including congenital heart and hypertensive disease
 - 7 - Arrhythmias and conduction disorders
 - 9 - Chest pain
 - 10 - Syncope
 - 11 - Acute stroke/transient ischemic attack
 - 12 - Pulmonary embolism/deep venous thrombosis
 - 13 - Other peripheral vascular disease
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eTable 4: Modified Condition Categories for Pulmonary Diagnoses.

Modified condition category codes for pulmonary diagnoses

- 8 - Pleural effusion/pneumothorax
 - 14 - Cardio-respiratory failure
 - 15 - Chronic obstructive pulmonary disease/asthma
 - 16 - Pneumonia including aspiration pneumonitis
 - 25 - Fibrosis of lung and other chronic lung disorders
 - 28 - Other lung disorders including acute, congenital, and unspecified lung abnormalities
 - 29 - Primary cancer of the trachea, bronchus, lung, and pleura
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eTable 5: Common Comorbidities among 30-Day Readmissions for Patients Hospitalized with Heart Failure, Acute Myocardial Infarction, or Pneumonia.

Rank	30-day readmissions after heart failure hospitalization (329,308)		30-day readmissions after acute myocardial infarction hospitalization (108,992)		30-day readmissions after pneumonia hospitalization (214,239)	
	Comorbidity name	Percentage of readmissions	Comorbidity name	Percentage of readmissions	Comorbidity name	Percentage of readmissions
1	Coronary atherosclerosis or angina	76.73%	Congestive heart failure	64.36%	Gastrointestinal disorders	62.97%
2	Specified arrhythmias	71.34%	Specified arrhythmias	57.19%	Chronic obstructive pulmonary disease	62.10%
3	Iron deficiency or other anemias	59.67%	Diabetes or associated complications	48.59%	Iron deficiency or other anemias	57.73%
4	Other gastrointestinal disorders	58.56%	Iron deficiency or other anemias	46.87%	Coronary atherosclerosis or angina	53.73%
5	Vascular or circulatory disease	56.46%	Disorders of fluid, electrolyte, acid-base	44.83%	Congestive heart failure	52.77%
6	Diabetes or associated complications	55.12%	Renal failure	42.14%	Other lung disorders	52.41%
7	Disorders of fluid, electrolyte, and acid-base	53.70%	Valvular or rheumatic heart disease	38.82%	Disorders of fluid, electrolyte, and acid-base	52.09%
8	Renal failure	52.78%	Chronic obstructive pulmonary disease	38.23%	Specified arrhythmias	50.30%
9	Chronic obstructive pulmonary disease	52.45%	History of infection	32.65%	Vascular or circulatory disease	48.96%
10	Valvular or rheumatic heart disease	51.80%	Pneumonia	32.15%	History of infection	43.76%

eTable 6: Ranked 30-Day Readmission Diagnoses by Modified Condition Category for Patients Hospitalized with Heart Failure, Acute Myocardial Infarction, or Pneumonia.

Rank	30-day readmissions after heart failure hospitalization (329,308)		30-day readmissions after acute myocardial infarction hospitalization (108,992)		30-day readmissions after pneumonia hospitalization (214,239)	
	Diagnosis by mCC	Percentage of readmissions	Diagnosis by mCC	Percentage of readmissions	Diagnosis by mCC	Percentage of readmissions
1	Heart failure	35.22%	Heart failure	19.27%	Pneumonia including aspiration pneumonitis	22.36%
2	Renal disorders including renal failure and fluid, electrolyte, and acid-base abnormalities	8.11%	Acute myocardial infarction	9.95%	Heart failure	8.53%
3	Pneumonia including aspiration pneumonitis	4.98%	Renal disorders including renal failure and fluid, electrolyte, and acid-base abnormalities	5.28%	Chronic obstructive pulmonary disease/asthma	7.51%
4	Arrhythmias and conduction disorders	4.04%	Arrhythmias and conduction disorders	4.95%	Septicemia/shock	5.95%
5	Septicemia/shock	3.55%	Pneumonia including aspiration pneumonitis	4.89%	Renal disorders including renal failure and fluid, electrolyte, and acid-base abnormalities	5.27%
6	Cardio-respiratory failure	3.50%	Chronic angina and coronary artery disease	4.85%	Cardio-respiratory failure	4.89%
7	Chronic obstructive pulmonary disease/asthma	3.14%	Septicemia/shock	3.96%	Arrhythmias and conduction disorders	2.88%
8	Chronic angina and coronary artery disease	2.36%	Complications of care	3.86%	Clostridium difficile-associated infection	2.54%
9	Acute myocardial infarction	2.32%	Cardio-respiratory failure	3.14%	Urinary tract infection and urinary system complaints	2.06%
10	Complications of care	2.18%	Gastrointestinal hemorrhage	3.09%	Gastrointestinal hemorrhage	1.94%
11	Other peripheral	2.18%	Acute stroke/transient	2.88%	Acute stroke/transient	1.93%

12	vascular disease Gastrointestinal hemorrhage	2.06%	ischemic attack Chest pain	2.85%	ischemic attack Other peripheral vascular disease	1.72%
13	Acute stroke/transient ischemic attack	2.01%	Other peripheral vascular disease	2.78%	Complications of care	1.61%
14	Valvular/rheumatic heart disease	1.82%	Chronic obstructive pulmonary disease/asthma	2.01%	Pulmonary embolism/deep venous thrombosis	1.60%
15	Urinary tract infection and urinary system complaints	1.78%	Urinary tract infection and urinary system complaints	1.85%	Acute myocardial infarction	1.46%
16	Diabetes and its complications	1.32%	Unstable angina and other acute ischemic heart disease	1.63%	Primary cancer of the trachea, bronchus, lung, and pleura	1.26%
17	Chest pain	0.93%	Pulmonary embolism/deep venous thrombosis	1.54%	Pleural effusion/pneumothorax	1.24%
18	Hip fracture	0.89%	Diabetes and its complications	1.20%	Hip fracture	1.23%
19	Clostridium difficile-associated infection	0.88%	Anemia	1.11%	Diabetes and its complications	0.98%
20	Anemia	0.88%	Other cardiac disease including congenital heart and hypertensive disease	0.99%	Chronic angina and coronary artery disease	0.94%
21	Cellulitis	0.74%	Clostridium difficile-associated infection	0.95%	Fibrosis of lung and other chronic lung disorders	0.92%
22	Pulmonary embolism/deep venous thrombosis	0.65%	Syncope	0.91%	Anemia	0.90%
23	Pleural effusion/pneumothorax	0.64%	Valvular/rheumatic heart disease	0.82%	Chest pain	0.79%
24	Syncope	0.62%	Hip fracture	0.69%	Cellulitis	0.71%
25	Other cardiac disease including congenital heart and hypertensive disease	0.56%	Pleural effusion/pneumothorax	0.64%	Other lung disorders including acute, congenital, and unspecified lung abnormalities	0.58%
26	Other lung disorders including acute, congenital, and unspecified lung	0.28%	Cellulitis	0.53%	Syncope	0.55%

	abnormalities					
27	Fibrosis of lung and other chronic lung disorders	0.26%	Other lung disorders including acute, congenital, and unspecified lung abnormalities	0.27%	Other cardiac disease including congenital heart and hypertensive disease	0.42%
28	Primary cancer of the trachea, bronchus, lung, and pleura	0.18%	Primary cancer of the trachea, bronchus, lung, and pleura	0.23%	Valvular/rheumatic heart disease	0.39%
29	Unstable angina and other acute ischemic heart disease	0.12%	Fibrosis of lung and other chronic lung disorders	0.16%	Unstable angina and other acute ischemic heart disease	0.09%
30	Other	11.82%	Other	12.70%	Other	17.13%

mCC: modified condition category

eTable 7: Association of Readmission Diagnoses by Modified Condition Category with Median Time to Readmission for Patients Hospitalized with Heart Failure, Acute Myocardial Infarction, or Pneumonia.

Reason for index hospitalization	Top 5 readmission diagnoses by modified condition category	Median time to readmission in days (Q1-Q3 in days)
Heart failure	Heart failure	13 (6-21)
	Renal disorders including renal failure and fluid, electrolyte, and acid-base abnormalities	11 (6-19)
	Pneumonia including aspiration pneumonitis	12 (6-20)
	Arrhythmias and conduction disorders	12 (6-20)
	Septicemia/shock	11 (5-19)
Acute myocardial infarction	All heart failure readmissions	12 (6-20)
	Heart failure	10 (4-18)
	Acute myocardial infarction	9 (4-17)
	Renal disorders including renal failure and fluid, electrolyte, and acid-base abnormalities	11 (6-19)
	Arrhythmias and conduction disorders	10 (4-18)
Pneumonia	Pneumonia including aspiration pneumonitis	9 (4-18)
	All acute myocardial infarction readmissions	10 (4-18)
	Pneumonia including aspiration pneumonitis	11 (5-19)
	Heart failure	12 (6-20)
	Chronic obstructive pulmonary disease/asthma	14 (7-21)
	Septicemia/shock	12 (6-20)
	Renal disorders including renal failure and fluid, electrolyte, and acid-base abnormalities	11 (6-19)
All pneumonia readmissions	12 (6-20)	

eTable 8: Association of Patient Characteristics with the Comorbidity-adjusted Odds of Readmission for Common Readmission Diagnoses by Modified Condition Category for Patients Hospitalized with Heart Failure, Acute Myocardial Infarction, or Pneumonia.

Reason for readmission by modified condition category	Odds ratio by patient age in years (95% CI)			Odds ratio by patient sex (95% CI)		Odds ratio by patient race (95% CI)		
	65-74	75-84	≥85	Male	Female	White	Black	Other
Heart failure cohort								
Heart failure	1	0.99 (0.97, 1.01)	1.07 (1.05, 1.10)	1	0.98 (0.95, 0.98)	1	1.22 (1.19, 1.25)	1.07 (1.03, 1.11)
Renal disorders	1	1.04 (1.00, 1.07)	1.06 (1.03, 1.10)	1	1.01 (0.98, 1.04)	1	1.05 (1.01, 1.09)	1.01 (0.95, 1.07)
Pneumonia	1	1.21 (1.16, 1.27)	1.59 (1.51, 1.68)	1	0.81 (0.78, 0.84)	1	0.74 (0.70, 0.79)	0.92 (0.85, 0.99)
Arrhythmias and conduction disorders	1	0.93 (0.89, 0.97)	0.77 (0.73, 0.81)	1	1.15 (1.11, 1.20)	1	0.78 (0.74, 0.83)	0.81 (0.74, 0.89)
Septicemia/shock	1	1.16 (1.10, 1.22)	1.26 (1.20, 1.34)	1	0.91 (0.87, 0.94)	1	1.00 (0.95, 1.06)	1.22 (1.13, 1.33)
Cardiovascular diagnoses	1	0.96 (0.94, 0.97)	0.95 (0.93, 0.97)	1	0.99 (0.97, 1.00)	1	1.15 (1.12, 1.17)	1.03 (0.99, 1.06)
Acute myocardial infarction cohort								
Heart failure	1	1.18 (1.14, 1.23)	1.44 (1.38, 1.50)	1	1.07 (1.04, 1.10)	1	0.99 (0.94, 1.05)	1.05 (0.98, 1.13)
Acute myocardial infarction	1	1.04 (0.99, 1.09)	1.51 (1.43, 1.60)	1	0.90 (0.87, 0.94)	1	1.03 (0.98, 1.10)	1.03 (0.94, 1.14)
Renal disorders	1	1.15 (1.07, 1.23)	1.18 (1.09, 1.27)	1	0.98 (0.91, 1.01)	1	1.39 (1.28, 1.51)	1.10 (0.97, 1.25)
Arrhythmias and conduction disorders	1	0.95 (0.89, 1.02)	0.83 (0.77, 0.90)	1	0.90 (0.85, 0.95)	1	0.58 (0.51, 0.65)	0.84 (0.73, 0.96)
Pneumonia	1	1.21 (1.12, 1.30)	1.58 (1.44, 1.68)	1	0.69 (0.65, 0.73)	1	0.91 (0.82, 1.01)	0.97 (0.84, 1.11)