Supplementary Online Content

Silva GC, Jiang L, Gutman R, et al. Mortality trends for veterans hospitalized with heart failure and pneumonia using claims-based vs clinical risk-adjustment variables [published online December 20, 2019]. *JAMA Intern Med*. doi:10.1001/jamainternmed.2019.5970

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

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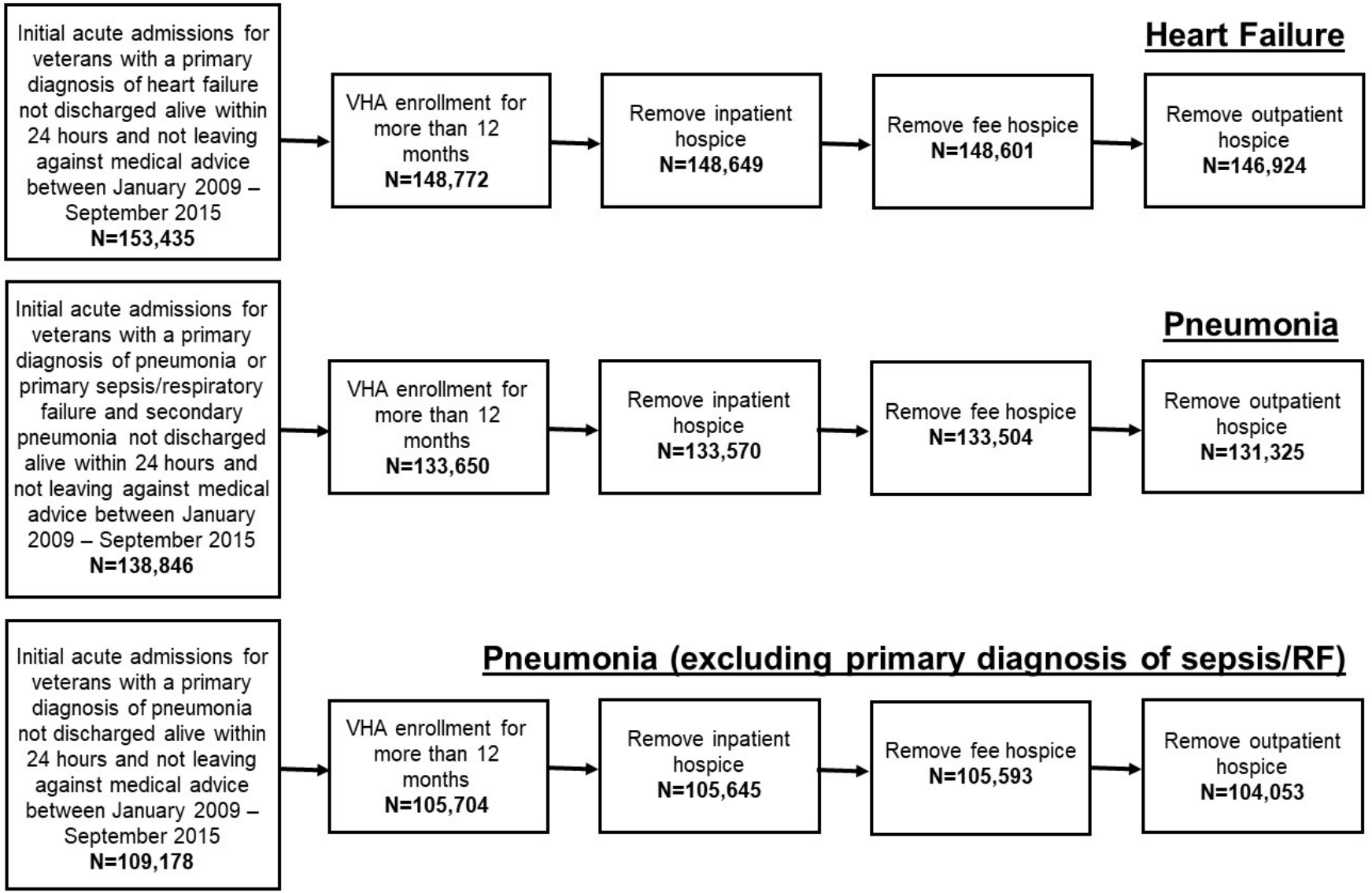
eFigure 1. Exclusion Flowchart for the Study Population



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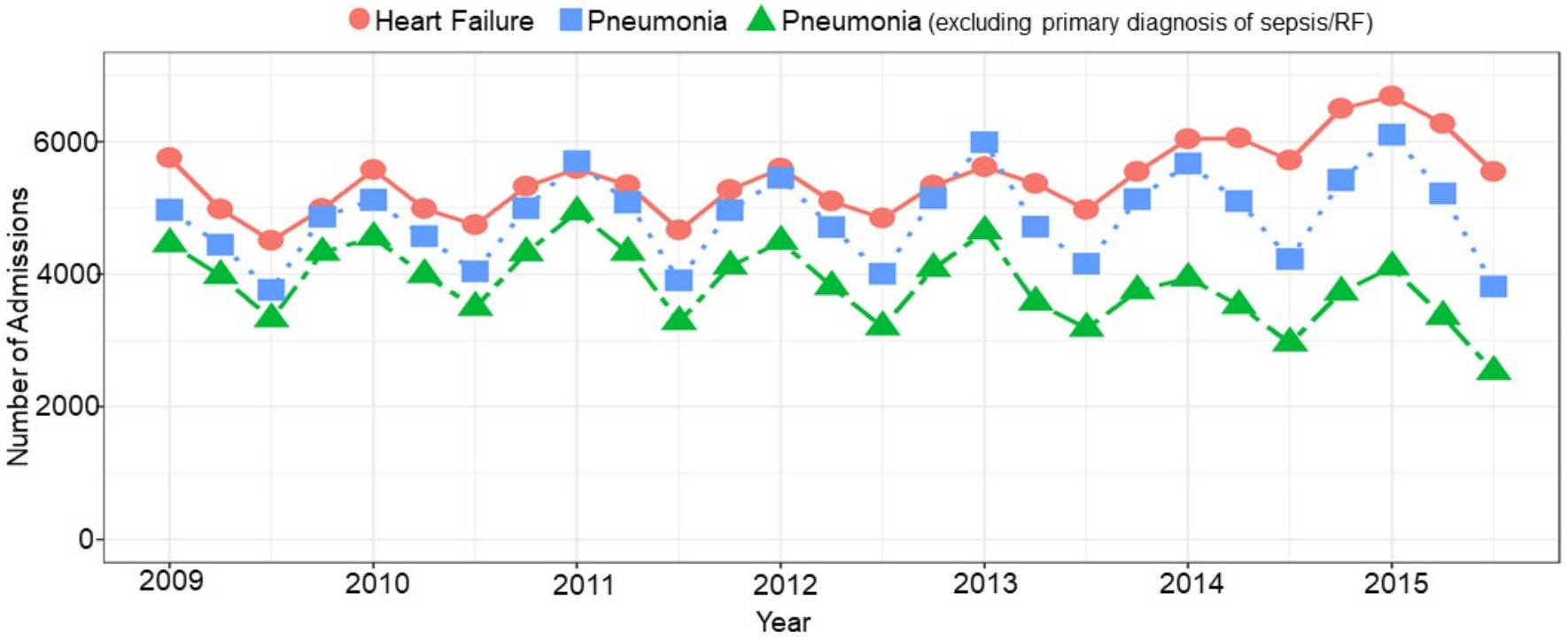
eFigure 2. Number of Admissions Per Quarter in the Study Population



Each point corresponds to the number of admissions for each quarter between January-March 2009 to July-September 2015

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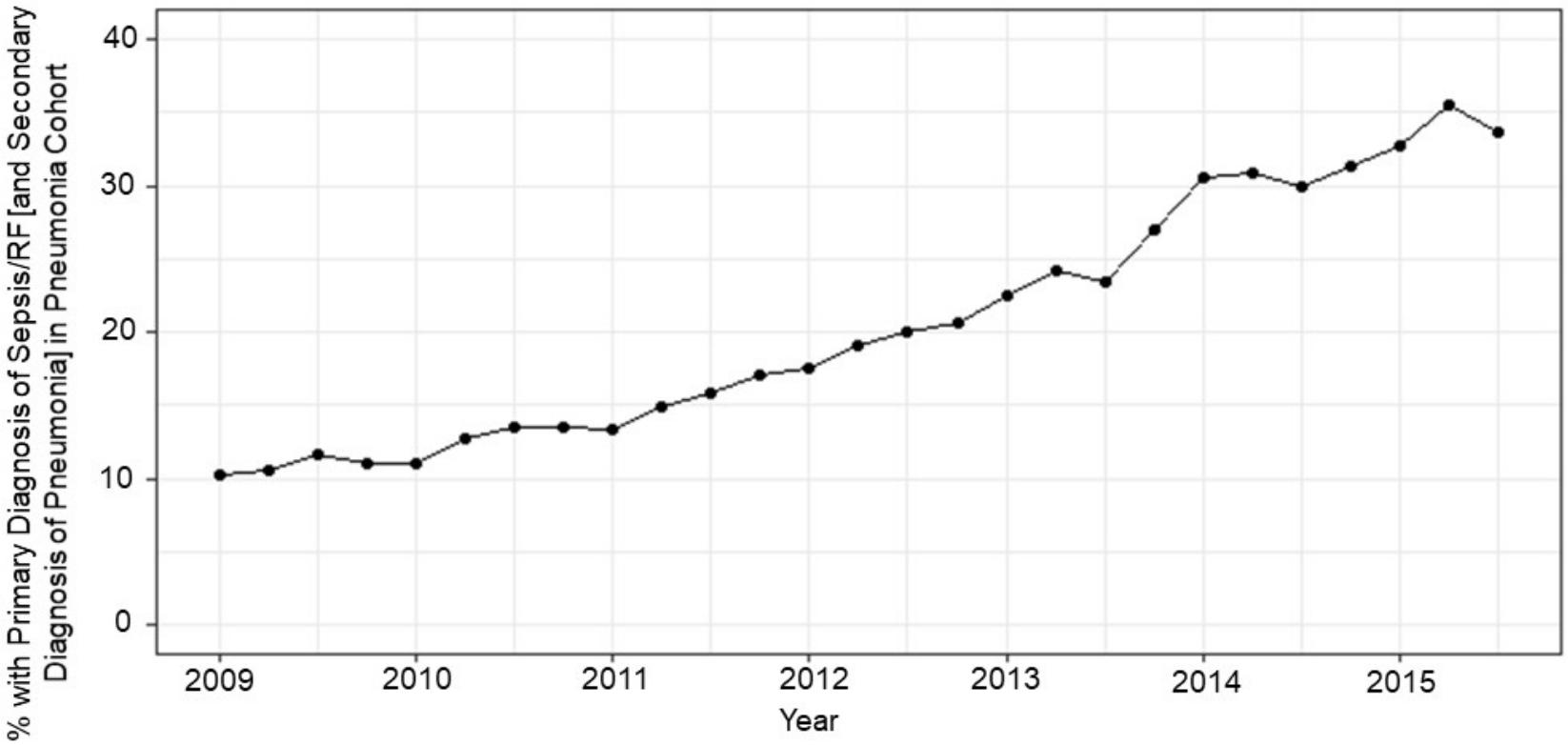
eFigure 3. Percent of Admissions per Quarter with a Primary Diagnosis of Sepsis/RF [with Pneumonia as Secondary Diagnosis] in Pneumonia Cohort



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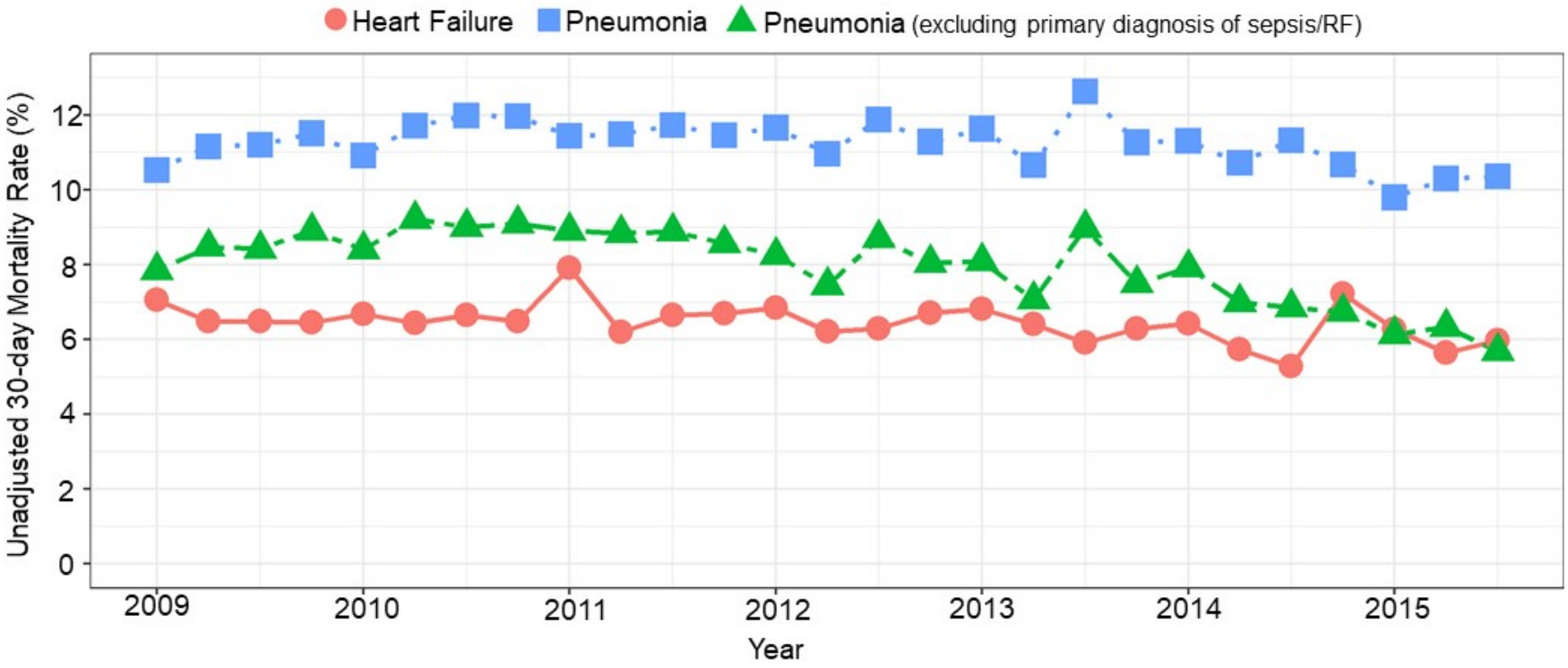
eFigure 4. Unadjusted 30-day Mortality Rates for Veterans Hospitalized with Heart Failure and Pneumonia



Each point corresponds to the unadjusted mortality rate for each quarter between January-March 2009 to July-September 2015

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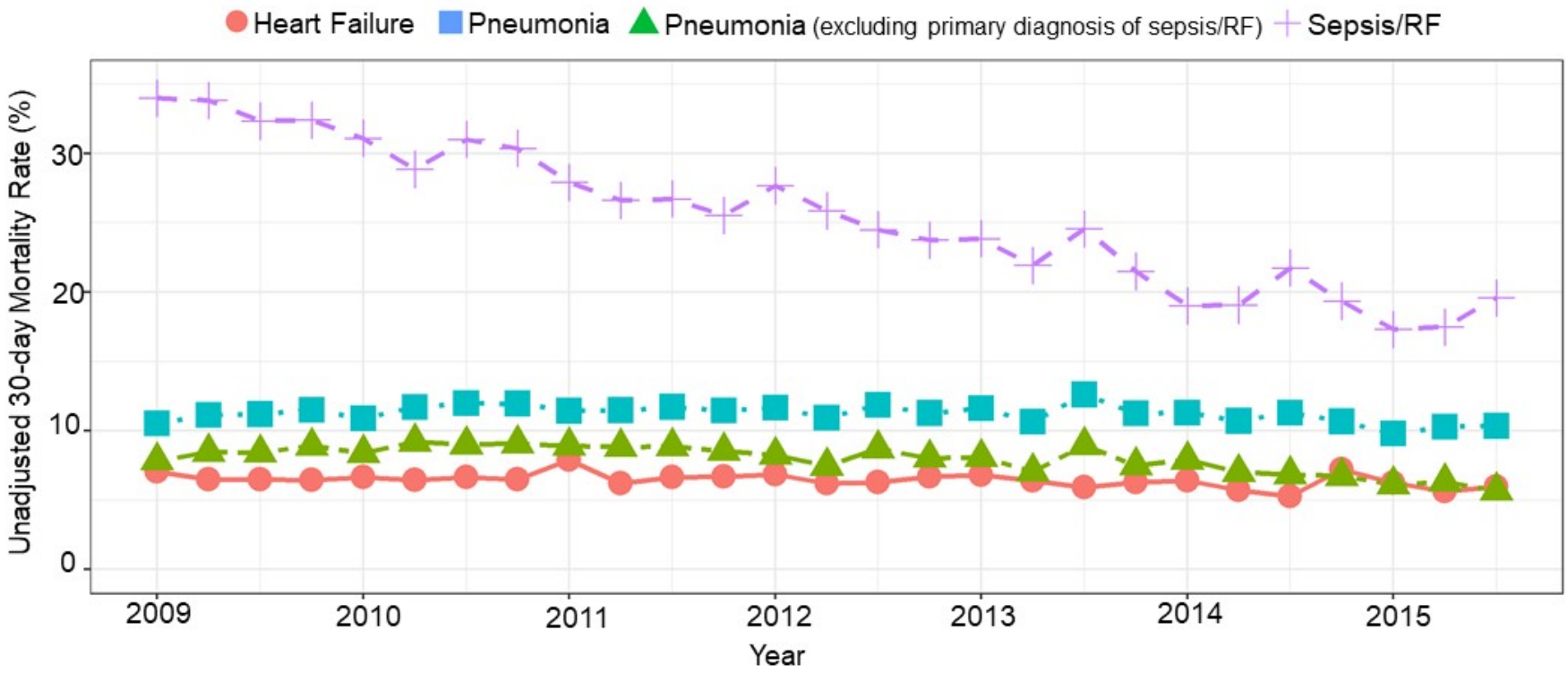
eFigure 5. Unadjusted 30-day Mortality Rates for Veterans Hospitalized with Heart Failure, Pneumonia, Pneumonia [excluding Sepsis/RF] and Sepsis/RF [with Pneumonia as Secondary Diagnosis]



Each point corresponds to the unadjusted mortality rate for each quarter between January-March 2009 to July-September 2015

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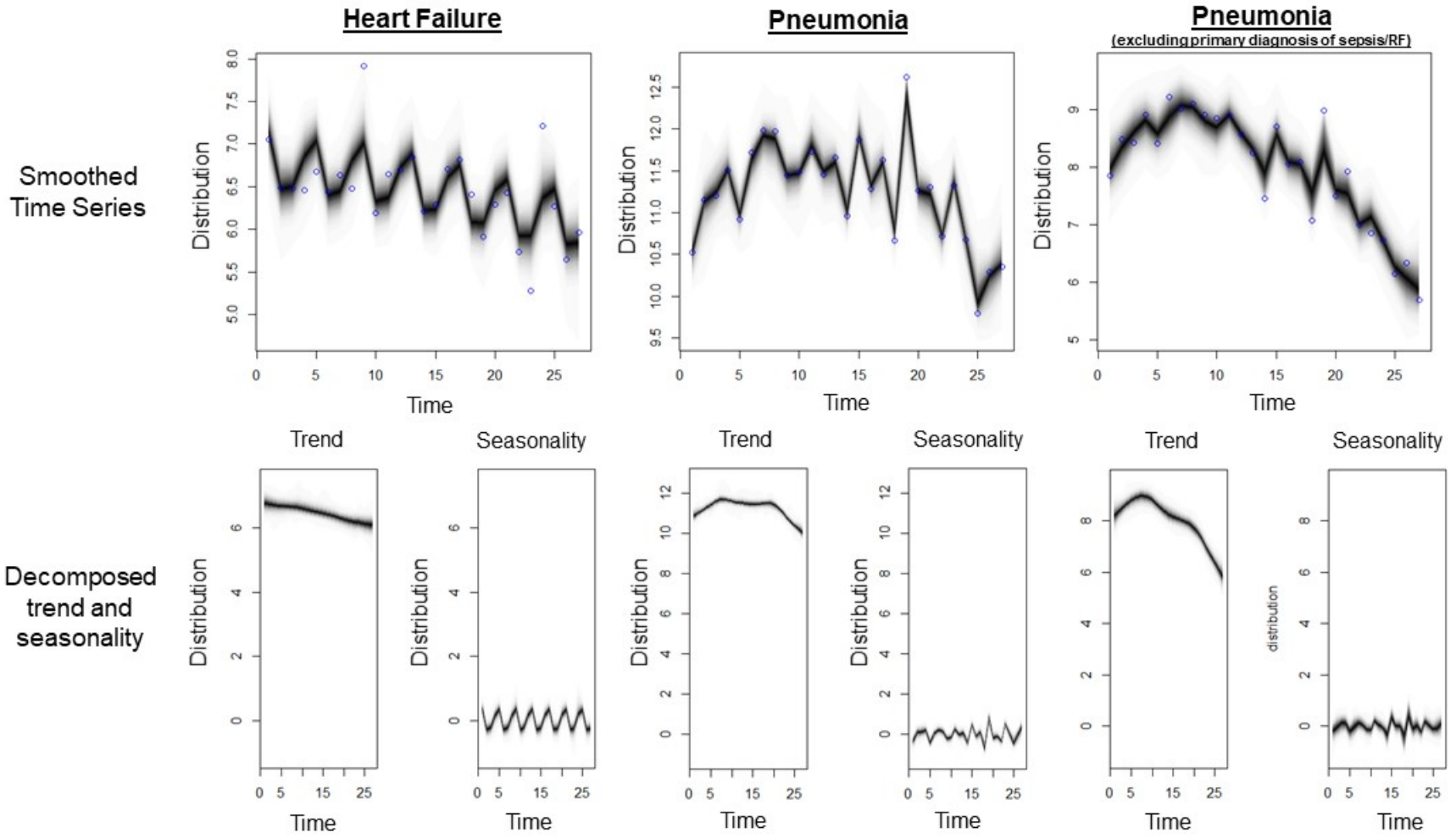
eFigure 6. Bayesian Structural Time Series Analyses



Bayesian Structural Time Series Models work with time series data and can decompose a time series into its state components like trend and seasonality. Time refers to admission quarter. This model extracts the trend from unadjusted 30-day mortality rates upon having accounted for its seasonal variations.

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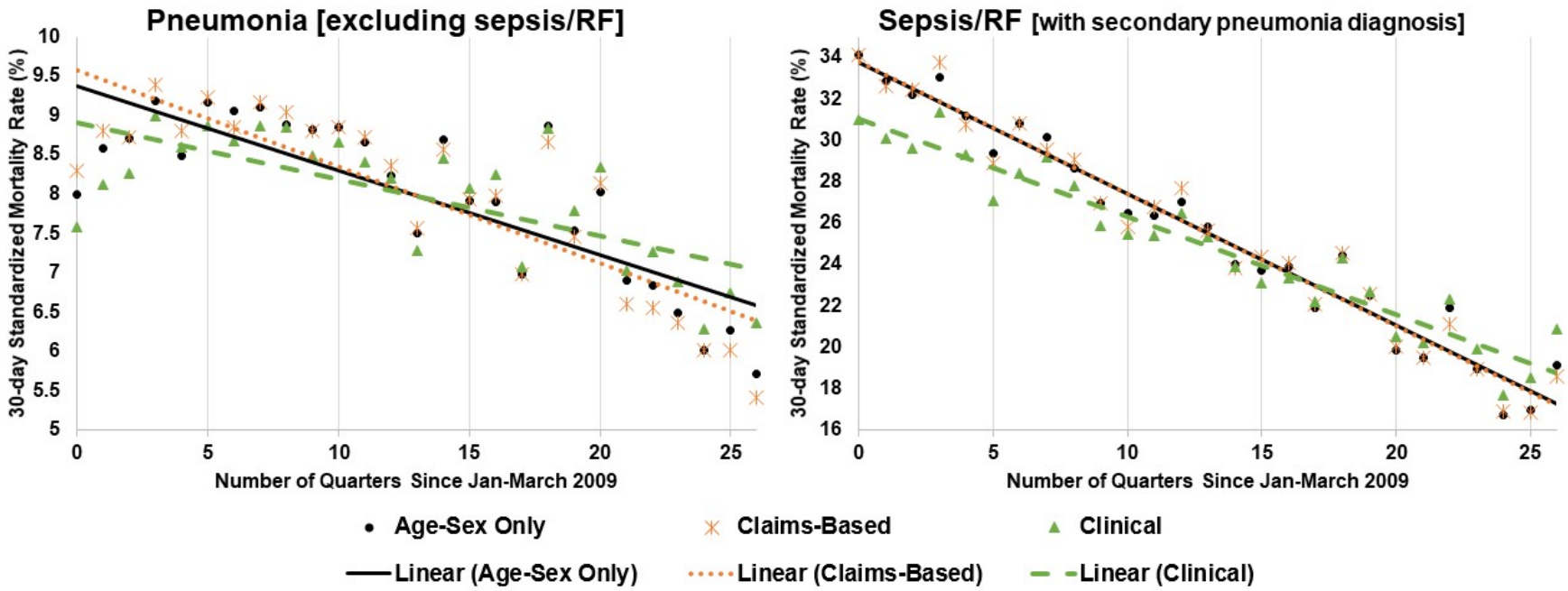
eFigure 7. Risk-Standardized 30-Day Mortality Rates Among Veterans Hospitalized with Pneumonia [excluding Sepsis/RF] and Sepsis/RF [with Pneumonia as Secondary Diagnosis] from Claims-Based and Clinical Risk-Adjustment Models



Caption: Each point corresponds to the risk-standardized 30-day mortality rate in each quarter between January-March 2009 and July-September 2015 for the reference population of interest.

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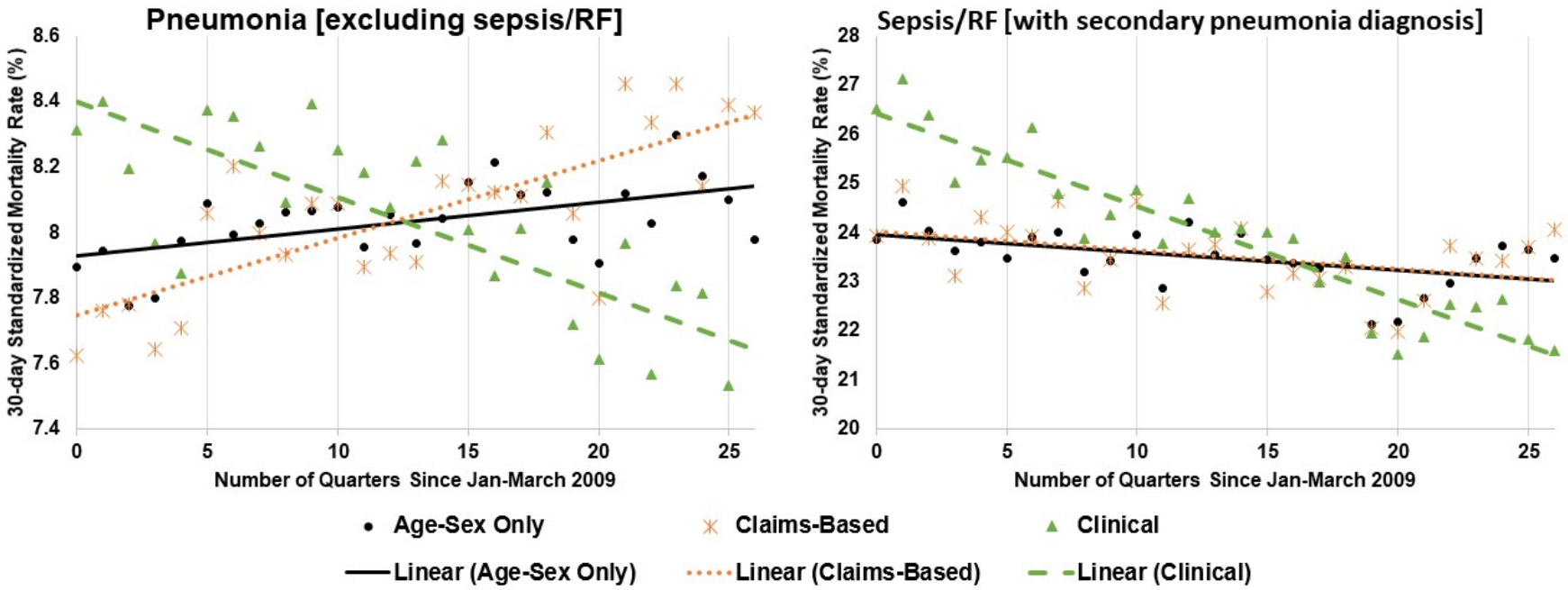
eFigure 8. Quarterly Trends in Predicted Risk of 30-day Mortality, as Derived from Clinical and Claims-Based Risk-adjustment Models for Pneumonia [excluding Sepsis/RF] and Sepsis/RF [with Pneumonia as Secondary Diagnosis]



Caption: Each point corresponds to the predicted risk of 30-day mortality in each quarter between January-March 2009 and July-September 2015.

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eTable 1. ICD-9 Codes for Primary Diagnoses

Primary Diagnoses	ICD-9 Codes/Descriptions
Heart Failure	402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, and 428.9
Pneumonia	480.0, 480.1, 480.2, 480.3, 480.8, 480.9, 481, 482.0, 482.1, 482.2, 482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.42, 482.49, 482.81, 482.82, 482.83, 482.84, 482.89, 482.9, 483.0, 483.1, 483.8, 485, 486, 487.0, and 488.11
Sepsis or RF [with secondary diagnosis of pneumonia]	38 STREPTOCOCCAL SEPTICEMIA 38.1 STAPHYLOCOCCAL SEPTICEMIA 38.1 STAPHYLOCOCCAL SEPTICEMIA, UNSPECIFIED 38.11 STAPHYLOCOCCUS AUREUS SEPTICEMIA 38.11 METHICILLIN SUSCEPTIBLE STAPHYLOCOCCUS AUREUS SEPTICEMIA 38.12 METHICILLIN RESISTANT STAPHYLOCOCCUS AUREUS SEPTICEMIA 38.19 OTHER STAPHYLOCOCCAL SEPTICEMIA 38.2 PNEUMOCOCCAL SEPTICEMIA 38.3 SEPTICEMIA DUE TO ANAEROBES 38.4 SEPTICEMIA DUE TO GRAM-NEGATIVE ORGANISM, UNSPECIFIED 38.41 SEPTICEMIA DUE TO HEMOPHILUS INFLUENZAE (H. INFLUENZAE) 38.42 SEPTICEMIA DUE TO ESCHERICHIA COLI (E. COLI) 38.43 SEPTICEMIA DUE TO PSEUDOMONAS 38.44 SEPTICEMIA DUE TO SERRATIA 38.49 OTHER SEPTICEMIA DUE TO GRAM-NEGATIVE ORGANISMS 38.8 OTHER SPECIFIED SEPTICEMIAS 38.9 UNSPECIFIED SEPTICEMIA 518.81 ACUTE RESPIRATORY FAILURE 518.82 OTHER PULMONARY INSUFFICIENCY, NEC 518.84 ACUTE AND CHRONIC RESPIRATORY FAILURE 785.52 SEPTIC SHOCK 799.1 RESPIRATORY ARREST 995.91 SEPSIS 995.92 SEVERE SEPSIS

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eTable 2. Summary of Missing Data for Adjustment/Summary Variables

Variable	Heart Failure (n=146,924)		Pneumonia (n=131,325)		Pneumonia [excluding Sepsis/RF] (n=104,053)	
	Number Missing	%	Number Missing	%	Number Missing	%
Systolic Blood Pressure	3,146	2.1	2,467	1.9	1,326	1.3
Diastolic Blood Pressure	1,340	0.9	308	0.2	153	0.1
Heart Rate	66	<0.1	25	<0.1	13	<0.1
Respiratory Rate	1,158	0.8	45	<0.1	16	<0.1
Blood Urea Nitrogen	8,834	6.0	7,658	5.8	5,548	5.3
Oxygen Saturation	811	0.6	33	<0.1	14	<0.1
Creatinine	1,505	1.0	1,067	0.8	915	0.9
Potassium	5,211	3.5	4,139	3.2	3,479	3.3
Hematocrit	6,162	4.2	5,740	4.4	5,018	4.8
B-type Natriuretic Peptide	18,631	12.7	-	-	-	-
Body Mass Index	22,059	15.0	11,310	8.6	8,217	7.9
Left- Ventricular Ejection Fraction	49,043	33.4	-	-	-	-
Sodium	4,524	3.1	3,567	2.7	2,972	2.9
Serum Glucose	-	-	4,892	3.7	4,102	3.9
Area Deprivation Index	1,741	1.2	2,044	1.6	1,373	1.3
Race/Ethnicity	749	0.5	889	0.7	666	0.6

Note: The number of missing values for Sepsis/RF can be calculated by subtracting the number missing for Pneumonia [excluding Sepsis/RF] from the number missing for Pneumonia.

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eTable 3. Characteristics of Veterans Hospitalized with Pneumonia [excluding primary diagnosis of Sepsis/RF] Between the First and Last Years of the Study

Characteristic		First Year[a] (n=16,091)	Last Year[b] (n=13,727)	Standardized Difference
Age (years)		69.9 ± 12.7	71.9 ± 12.1	0.16
Male		15,642 (97.2)	13,263 (96.6)	0.03
Claims-Based Comorbid Conditions	Percutaneous Transluminal Coronary Angioplasty	656 (4.1)	782 (5.7)	0.08
	Coronary Artery Bypass Graft	1,312 (8.2)	1,019 (7.4)	0.03
	Congestive Heart Failure	4,332 (26.9)	4,030 (29.4)	0.05
	Acute Myocardial Infarction	416 (2.6)	339 (2.5)	0.01
	Ischemic Heart Disease	649 (4.0)	685 (5.0)	0.05
	Chronic Atherosclerosis	5,843 (36.3)	5,083 (37.0)	0.02
	Cardiorespiratory Failure and Shock	2,132 (13.2)	2,718 (19.8)	0.18
	Hypertension	11,838 (73.6)	10,417 (75.9)	0.05
	Stroke	1,431 (8.9)	1,247 (9.1)	0.01
	Cerebrovascular	1,675 (10.4)	1,521 (11.1)	0.02
	Renal Failure	3,822 (23.8)	4,251 (31.0)	0.16
	Chronic Obstructive Pulmonary Disease	7,820 (48.6)	7,032 (51.2)	0.05
	Pneumonia	5,834 (36.3)	5,537 (40.3)	0.08
	Malnutrition	709 (4.4)	705 (5.1)	0.03
	Dementia/Senility	2,175 (13.5)	2,115 (15.4)	0.05
	Functional Disability	1,451 (9.0)	1,202 (8.8)	0.01
	Peripheral Vascular Disease	3,432 (21.3)	3,267 (23.8)	0.06
	Cancer	1,729 (10.7)	1,632 (11.9)	0.04
	Trauma	4,426 (27.5)	4,007 (29.2)	0.04
	Major Psychiatric Disease	2,926 (18.2)	2,780 (20.3)	0.05
	Chronic Liver Disease	885 (5.5)	893 (6.5)	0.04
	Hematological Disorder	435 (2.7)	310 (2.3)	0.03
	Iron Deficiency	5,715 (35.5)	5,161 (37.6)	0.04
	Depression	3,853 (23.9)	3,521 (25.7)	0.04
	Parkinson's Disease	393 (2.4)	348 (2.5)	0.01
	Seizure Disorder	759 (4.7)	611 (4.5)	0.01
	Lung Fibrosis	1,208 (7.5)	1,143 (8.3)	0.03
	Asthma	914 (5.7)	855 (6.2)	0.02
	Vertebral Fracture	182 (1.1)	235 (1.7)	0.05
	Surgical Admission	645 (4.0)	545 (4.0)	0.00
	Number of Claims-Based Comorbidities	4.9 ± 3.1	5.4 ± 3.2	0.14
Clinical	Systolic Blood Pressure (mmHg) †	127.6 ± 22.7	130.5 ± 21.7	0.13
	Diastolic Blood Pressure (mmHg) †	71.0 ± 15.0	71.9 ± 13.2	0.07
	Heart Rate †	89.4 ± 18.6	87.5 ± 17.2	0.11
	Respiratory Rate †	21.6 ± 14.2	19.7 ± 5.1	0.17
	Oxygen Saturation (%) †	94.4 ± 6.6	94.9 ± 3.3	0.10
	Body Mass Index (kg/m^2) †	27.0 ± 6.9	27.5 ± 6.9	0.07
	Sodium (mEq/L) †	136.6 ± 4.6	136.6 ± 4.4	0.00
	Potassium (mEq/L) †	4.1 ± 0.6	4.1 ± 0.5	0.02
	Blood Urea Nitrogen (mg/dL) †	23.0 ± 13.9	22.6 ± 13.5	0.03
	Creatinine (mg/dL) †	1.4 ± 1.1	1.4 ± 1.2	0.02
	Hematocrit (%) †	36.5 ± 5.9	37.1 ± 6.2	0.09
	Serum Glucose (mg/dL) †	136.2 ± 52.6	137.4 ± 53.7	0.02
	Inpatient admission 30 days prior	2,886 (17.9)	2,751 (20.0)	0.05

Mean ± SD reported for continuous variables; Count (Rate) reported for categorical variables

[a:] First Year=January 2009 – December 2009

[b:] Last Year = October 2014 – September 2015

†: Summary statistics reported among non-missing values

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eTable 4. Characteristics of Veterans Hospitalized with Sepsis/RF [with Pneumonia as Secondary Diagnosis] Between the First and Last Years of the Study

Characteristic		First Year[a] (n=1,958)	Last Year[b] (n=6,828)	Standardized Difference
Age (years)		69.6 ± 11.6	70.9 ± 11.8	0.11
Male		1,904 (97.2)	6,609 (96.8)	0.03
Claims-Based Comorbid Conditions	Percutaneous Transluminal Coronary Angioplasty	81 (4.1)	378 (5.5)	0.06
	Coronary Artery Bypass Graft	159 (8.1)	473 (6.9)	0.04
	Congestive Heart Failure	619 (31.6)	2,236 (32.7)	0.02
	Acute Myocardial Infarction	80 (4.1)	270 (4.0)	0.01
	Ischemic Heart Disease	100 (5.1)	418 (6.1)	0.04
	Chronic Atherosclerosis	679 (34.7)	2,423 (35.5)	0.02
	Cardiorespiratory Failure and Shock	496 (25.3)	2,034 (29.8)	0.10
	Hypertension	1,464 (74.8)	5,206 (76.2)	0.03
	Stroke	191 (9.8)	646 (9.5)	0.01
	Cerebrovascular	223 (11.4)	769 (11.3)	0.00
	Renal Failure	559 (28.5)	2,427 (35.5)	0.15
	Chronic Obstructive Pulmonary Disease	970 (49.5)	3,518 (51.5)	0.04
	Pneumonia	702 (35.9)	2,769 (40.6)	0.10
	Malnutrition	128 (6.5)	519 (7.6)	0.04
	Dementia/Senility	295 (15.1)	1,186 (17.4)	0.06
	Functional Disability	232 (11.8)	756 (11.1)	0.02
	Peripheral Vascular Disease	432 (22.1)	1,761 (25.8)	0.09
	Cancer	238 (12.2)	915 (13.4)	0.04
	Trauma	566 (28.9)	2,035 (29.8)	0.02
	Major Psychiatric Disease	372 (19.0)	1,371 (20.1)	0.03
	Chronic Liver Disease	150 (7.7)	565 (8.3)	0.02
	Hematological Disorder	63 (3.2)	161 (2.4)	0.05
	Iron Deficiency	768 (39.2)	2,739 (40.1)	0.02
	Depression	459 (23.4)	1,769 (25.9)	0.06
	Parkinson's Disease	51 (2.6)	198 (2.9)	0.02
	Seizure Disorder	123 (6.3)	381 (5.6)	0.03
	Lung Fibrosis	166 (8.5)	553 (8.1)	0.01
	Asthma	81 (4.1)	374 (5.5)	0.06
	Vertebral Fracture	23 (1.2)	156 (2.3)	0.08
	Surgical Admission	93 (4.7)	391 (5.7)	0.04
	Number of Claims-Based Comorbidities	5.4 ± 3.3	5.8 ± 3.4	0.11
Clinical	Systolic Blood Pressure (mmHg) †	118.2 ± 26.4	124.8 ± 23.6	0.26
	Diastolic Blood Pressure (mmHg) †	68.0 ± 18.8	70.3 ± 14.6	0.14
	Heart Rate †	96.8 ± 22.0	94.7 ± 19.9	0.10
	Respiratory Rate †	24.3 ± 21.7	21.1 ± 10.6	0.19
	Oxygen Saturation (%) †	93.9 ± 10.5	94.8 ± 5.2	0.11
	Body Mass Index (kg/m^2) †	27.3 ± 8.2	27.4 ± 7.5	0.02
	Sodium (mEq/L) †	137.0 ± 6.1	136.7 ± 5.3	0.05
	Potassium (mEq/L) †	4.2 ± 0.7	4.1 ± 0.6	0.12
	Blood Urea Nitrogen (mg/dL) †	30.5 ± 17.8	26.6 ± 16.2	0.23
	Creatinine (mg/dL) †	1.8 ± 1.5	1.6 ± 1.4	0.12
	Hematocrit (%) †	35.8 ± 6.9	36.5 ± 6.8	0.09
	Serum Glucose (mg/dL) †	142.6 ± 59.1	144.6 ± 57.0	0.04
	Inpatient admission 30 days prior	456 (23.3)	1,537 (22.5)	0.02

Mean ± SD reported for continuous variables; Count (Rate) reported for categorical variables

[a:] First Year=January 2009 – December 2009

[b:] Last Year = October 2014 – September 2015

†: Summary statistics reported among non-missing values

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eTable 5. Characteristics of Veterans Hospitalized with Heart Failure in the First and Last Years of the Study

Characteristic		First Year[a] (n=20,228)	Last Year[b] (n=25,003)	Standardized Difference
Age (years)		71.3 ± 11.5	71.9 ± 11.2	0.05
Male		19,944 (98.6)	24,566 (98.3)	0.03
Claims-Based	Percutaneous Transluminal Coronary Angioplasty	1,718 (8.5)	3,105 (12.4)	0.13
	Coronary Artery Bypass Graft	4,454 (22.0)	4,826 (19.3)	0.07
	Congestive Heart Failure	15,986 (79.0)	20,353 (81.4)	0.06
	Acute Myocardial Infarction	1,552 (7.7)	2,096 (8.4)	0.03
	Ischemic Heart Disease	2,364 (11.7)	3,622 (14.5)	0.08
	Chronic Atherosclerosis	13,565 (67.1)	16,340 (65.4)	0.04
	Cardiorespiratory Failure and Shock	2,948 (14.6)	5,832 (23.3)	0.22
	Valvular/Rheumatic Heart Disease	4,612 (22.8)	5,892 (23.6)	0.02
	Hypertension	17,813 (88.1)	22,463 (89.8)	0.06
	Stroke	2,044 (10.1)	2,703 (10.8)	0.02
	Renal Failure	9,683 (47.9)	13,885 (55.5)	0.15
	Chronic Obstructive Pulmonary Disease	8,764 (43.3)	11,363 (45.4)	0.04
	Pneumonia	4,379 (21.6)	5,911 (23.6)	0.05
	Diabetes Mellitus with Complications	11,978 (59.2)	15,529 (62.1)	0.06
	Dementia/Senility	2,055 (10.2)	2,943 (11.8)	0.05
	Functional Disability	1,715 (8.5)	2,251 (9.0)	0.02
	Peripheral Vascular Disease	5,986 (29.6)	7,716 (30.9)	0.03
	Cancer	666 (3.3)	1,039 (4.2)	0.05
	Trauma	5,498 (27.2)	7,586 (30.3)	0.07
	Major Psychiatric Disease	2,662 (13.2)	3,900 (15.6)	0.07
	Chronic Liver Disease	1,122 (5.5)	2,057 (8.2)	0.11
	Surgical Admission	735 (3.6)	1,246 (5.0)	0.07
	Number of Claims-Based Comorbidities	6.0 ± 2.8	6.5 ± 3.0	0.16
Clinical	Systolic Blood Pressure (mmHg) †	126.7 ± 31.0	130.3 ± 29.1	0.12
	Diastolic Blood Pressure (mmHg) †	83.0 ± 25.2	81.4 ± 21.8	0.07
	Heart Rate †	80.1 ± 18.4	81.5 ± 18.8	0.08
	Respiratory Rate †	26.0 ± 33.7	22.3 ± 24.8	0.12
	Oxygen Saturation (%) †	93.2 ± 15.0	94.6 ± 10.7	0.11
	Body Mass Index (kg/m^2) †	30.9 ± 8.0	31.5 ± 7.9	0.08
	Sodium (mEq/L) †	138.4 ± 4.2	138.3 ± 4.2	0.02
	Potassium (mEq/L) †	4.2 ± 0.6	4.2 ± 0.6	0.04
	Blood Urea Nitrogen (mg/dL) †	30.4 ± 17.2	29.8 ± 16.9	0.04
	Creatinine (mg/dL) †	1.7 ± 0.9	1.7 ± 0.9	0.00
	B-type Natriuretic Peptide (pg/mL)†	1,346.7 ± 1,446.4	1,359.8 ± 1,592.0	0.01
	Hematocrit (%) †	36.4 ± 6.0	36.7 ± 6.3	0.06
	Left Ventricular Ejection Fraction (%) †	37.6 ± 15.6	38.4 ± 15.4	0.05

Mean ± SD reported for continuous variables; Count (Rate) reported for categorical variables

[a:] First Year=January 2009 – December 2009

[b:] Last Year = October 2014 – September 2015

†: Summary statistics reported among non-missing values

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eTable 6. Characteristics of Veterans Hospitalized with Pneumonia in the First and Last Years of the Study

Characteristic		First Year[a] (n=18,049)	Last Year[b] (n=20,555)	Standardized Difference
Age (years)		69.9 ± 12.6	71.6 ± 12.0	0.14
Male		17,546 (97.2)	19,872 (96.7)	0.03
Claims-Based Comorbid Conditions	Percutaneous Transluminal Coronary Angioplasty	737 (4.1)	1,160 (5.6)	0.07
	Coronary Artery Bypass Graft	1,471 (8.2)	1,492 (7.3)	0.03
	Congestive Heart Failure	4,951 (27.4)	6,266 (30.5)	0.07
	Acute Myocardial Infarction	496 (2.7)	609 (3.0)	0.01
	Ischemic Heart Disease	749 (4.1)	1,103 (5.4)	0.06
	Chronic Atherosclerosis	6,522 (36.1)	7,506 (36.5)	0.01
	Cardiorespiratory Failure and Shock	2,628 (14.6)	4,752 (23.1)	0.22
	Hypertension	13,302 (73.7)	15,623 (76.0)	0.05
	Stroke	1,622 (9.0)	1,893 (9.2)	0.01
	Cerebrovascular	1,898 (10.5)	2,290 (11.1)	0.02
	Renal Failure	4,381 (24.3)	6,678 (32.5)	0.18
	Chronic Obstructive Pulmonary Disease	8,790 (48.7)	10,550 (51.3)	0.05
	Pneumonia	6,536 (36.2)	8,306 (40.4)	0.09
	Malnutrition	837 (4.6)	1,224 (6.0)	0.06
	Dementia/Senility	2,470 (13.7)	3,301 (16.1)	0.07
	Functional Disability	1,683 (9.3)	1,958 (9.5)	0.01
	Peripheral Vascular Disease	3,864 (21.4)	5,028 (24.5)	0.07
	Cancer	1,967 (10.9)	2,547 (12.4)	0.05
	Trauma	4,992 (27.7)	6,042 (29.4)	0.04
	Major Psychiatric Disease	3,298 (18.3)	4,151 (20.2)	0.05
	Chronic Liver Disease	1,035 (5.7)	1,458 (7.1)	0.06
	Hematological Disorder	498 (2.8)	471 (2.3)	0.03
	Iron Deficiency	6,483 (35.9)	7,900 (38.4)	0.05
	Depression	4,312 (23.9)	5,290 (25.7)	0.04
	Parkinson's Disease	444 (2.5)	546 (2.7)	0.01
	Seizure Disorder	882 (4.9)	992 (4.8)	0.00
	Lung Fibrosis	1,374 (7.6)	1,696 (8.3)	0.02
	Asthma	995 (5.5)	1,229 (6.0)	0.02
	Vertebral Fracture	205 (1.1)	391 (1.9)	0.06
	Surgical Admission	738 (4.1)	936 (4.6)	0.02
	Number of Claims-Based Comorbidities	5.0 ± 3.1	5.5 ± 3.3	0.16
Clinical	Systolic Blood Pressure (mmHg) †	126.6 ± 23.3	128.6 ± 22.5	0.09
	Diastolic Blood Pressure (mmHg) †	70.6 ± 15.4	71.4 ± 13.7	0.05
	Heart Rate †	90.2 ± 19.1	89.9 ± 18.4	0.02
	Respiratory Rate †	21.8 ± 15.2	20.2 ± 7.4	0.14
	Oxygen Saturation (%) †	94.3 ± 7.1	94.9 ± 4.0	0.09
	Body Mass Index (kg/m^2) †	27.0 ± 7.0	27.5 ± 7.1	0.06
	Sodium (mEq/L) †	136.6 ± 4.8	136.6 ± 4.8	0.01
	Potassium (mEq/L) †	4.1 ± 0.6	4.1 ± 0.6	0.00
	Blood Urea Nitrogen (mg/dL) †	23.8 ± 14.6	23.9 ± 14.5	0.01
	Creatinine (mg/dL) †	1.4 ± 1.1	1.5 ± 1.3	0.04
	Hematocrit (%) †	36.4 ± 6.1	36.9 ± 6.4	0.07
	Serum Glucose (mg/dL) †	136.9 ± 53.4	139.8 ± 54.9	0.06
	Inpatient admission 30 days prior	3,342 (18.5)	4,288 (20.9)	0.06

Mean ± SD reported for continuous variables; Count (Rate) reported for categorical variables

[a:] First Year=January 2009 – December 2009

[b:] Last Year = October 2014 – September 2015

†: Summary statistics reported among non-missing values

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eTable 7. Comparison of Clinical Characteristics Between First and Last Years of Study for Patients Admitted with Heart Failure

			First year (n=20,228)	Last year (n=25,003)
Clinical	Systolic Blood Pressure (mmHg) †	>140	6,561 (33.5)	8,930 (36.3)
		<90	2,526 (12.9)	2,065 (8.4)
	Diastolic Blood Pressure (mmHg) †	>90	5,449 (27.3)	5,699 (23.0)
		<60	2,375 (11.9)	2,326 (9.4)
	Heart Rate †	>100	2,568 (12.7)	3,229 (12.9)
		<60	1,776 (8.8)	1,688 (6.8)
	Respiratory Rate †	>20	5,932 (29.6)	5,000 (20.1)
	Oxygen Saturation (%) †	<92	2,394 (11.9)	2,130 (8.5)
	Body Mass Index (kg/m^2) †	≥25	12,514 (76.9)	17,145 (78.8)
		≥30	7,711 (47.4)	11,186 (51.4)
		≤18.5	314 (1.9)	334 (1.5)
	Sodium (mEq/L) †	>145	452 (2.3)	528 (2.1)
		<135	2,826 (14.4)	3,793 (15.3)
	Potassium (mEq/L) †	≥5.5	548 (2.8)	563 (2.3)
		<3.5	1,841 (9.4)	2,259 (9.1)
	Blood Urea Nitrogen (mg/dL) †	>20	12,734 (66.4)	15,728 (64.9)
	Creatinine (mg/dL) †	>1.5	8,296 (41.5)	10,193 (41.0)
	B-type Natriuretic Peptide (pg/mL)†	>250	15,141 (87.1)	18,642 (85.0)
	Hematocrit (%) †	<30	2,742 (14.7)	3,719 (15.0)
	Left Ventricular Ejection Fraction (%) †	≤40	8,246 (59.2)	7,006 (57.2)

Notes: First year=January 2009-December 2009; Last year=October 2014-September 2015
Count (Rate) reported for all clinical variables and thresholds
†: Summary statistics reported among non-missing values

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eTable 8. Comparison of Clinical Characteristics Between First and Last Years of Study for Patients Admitted with Pneumonia

			Pneumonia		Pneumonia [excluding Sepsis/RF]	
			First year (n=18,049)	Last year (n=20,555)	First year (n=16,091)	Last year (n=13,727)
Clinical	Systolic Blood Pressure (mmHg) †	>140	4,640 (26.3)	5,760 (28.5)	4,268 (27.0)	4,140 (30.5)
		<90	730 (4.1)	526 (2.6)	500 (3.2)	198 (1.5)
	Diastolic Blood Pressure (mmHg) †	>90	1,552 (8.6)	1,574 (7.7)	1,380 (8.6)	1,029 (7.5)
		<60	4,022 (22.4)	3,780 (18.4)	3,381 (21.1)	2,248 (16.4)
	Heart Rate †	>100	5008 (27.8)	5430 (26.4)	4193 (26.1)	2954 (21.5)
		<60	577 (3.2)	561 (2.7)	516 (3.2)	409 (3.0)
	Respiratory Rate †	>20	6,077 (33.7)	5,519 (26.9)	5,155 (32.0)	3,105 (22.6)
	Oxygen Saturation (%) †	<92	2,660 (14.7)	2,460 (12.0)	2,277 (14.2)	1,529 (11.1)
	Body Mass Index (kg/m^2) †	≥25	9,166 (57.5)	11,214 (59.7)	8,275 (57.8)	7,665 (60.5)
		≥30	4,524 (28.4)	5,753 (30.6)	4,028 (28.1)	3,876 (30.6)
		≤18.5	1,276 (8.0)	1,305 (6.9)	1,099 (7.7)	838 (6.6)
	Sodium (mEq/L) †	>145	393 (2.2)	477 (2.3)	280 (1.8)	209 (1.5)
		<135	4,980 (28.3)	5,871 (28.7)	4,390 (27.9)	3,794 (27.8)
	Potassium (mEq/L) †	≥5.5	358 (2.0)	384 (1.9)	278 (1.8)	180 (1.3)
		<3.5	2,050 (11.7)	2,252 (11.1)	1,816 (11.6)	1,451 (10.7)
	Blood Urea Nitrogen (mg/dL) †	>20	8,177 (47.6)	9,417 (47.4)	7,000 (45.6)	5,883 (44.0)
	Creatinine (mg/dL) †	>1.5	4,584 (25.6)	5,366 (26.2)	3,805 (23.9)	3,202 (23.4)
	Hematocrit (%) †	<30	2,480 (14.9)	3,030 (14.8)	2,100 (14.1)	1,778 (13)
	Serum Glucose (mg/dL) †	>130	7,035 (40.6)	8,734 (42.9)	6,138 (39.8)	5,497 (40.5)
		<70	362 (2.1)	308 (1.5)	298 (1.9)	191 (1.4)

Notes: First year=January 2009-December 2009; Last year=October 2014-September 2015
Count (Rate) reported for all clinical variables and thresholds
†: Summary statistics reported among non-missing values

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eTable 9. Comparison of Sociodemographic Characteristics Between First and Last Years for Patients Admitted with Heart Failure or Pneumonia

			Heart Failure		Pneumonia	
			First year (n=20,228)	**Last year (n=25,003)**	**First year (n=18,049)**	**Last year (n=20,555)**
	Area Deprivation Index †		105.6±13.9	105.3±13.5	105.5±13.6	105.9±12.7
	Race/ Ethnicity†	White	13,894 (69.1)	16,746 (67.3)	13,902 (77.7)	15,851 (77.5)
		AA	5,195 (25.8)	6,994 (28.1)	2,755 (15.4)	3,156 (15.4)
		Hispanic	684 (3.4)	702 (2.8)	892 (5.0)	1,009 (4.9)
		Other	340 (1.7)	452 (1.8)	338 (1.9)	430 (2.1)

Notes: First year=January 2009-December 2009; Last year=October 2014-September 2015
Count (Rate) reported for all clinical variables and thresholds
†: Summary statistics reported among non-missing values

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eTable 10. Changes in 30-day Mortality among Veterans Admitted with Pneumonia [excluding Sepsis/RF] and Sepsis/RF [with Pneumonia as Secondary Diagnosis]

Adjustment Variables	Measure	Pneumonia [excluding Sepsis/RF]	Sepsis/RF
Adjusted for Age and Sex	30-day mortality, *%*		
	First year	8.62	33.07
	Last year	6.12	17.96
	Quarterly Change, *percentage points*	-0.107 (-0.139, -0.075)	-0.634 (-0.690, -0.579)
	AUC	0.652 (0.646, 0.658)	0.661 (0.653, 0.668)
Adjusted for Age, Sex and Claims-Based Comorbid Conditions	30-day mortality, *%*		
	First year	8.81	33.23
	Last year	5.95	17.82
	Quarterly Change, *percentage points*	-0.123 (-0.154, -0.091)	-0.638 (-0.694, -0.581)
	AUC	0.721 (0.716, 0.727)	0.712 (0.705, 0.719)
Adjusted for Age, Sex, and Clinical Covariates	30-day mortality, *%*		
	First year	8.25	30.51
	Last year	6.57	19.26
	Quarterly Change, *percentage points*	-0.072 (-0.101, -0.043)	-0.472 (-0.526, -0.417)
	AUC	0.747 (0.741, 0.752)	0.737 (0.730, 0.744)

Notes: First year=January 2009-December 2009; Last year=October 2014-September 2015

Point estimates (95% CIs) for quarterly changes were calculated using the slope of the linear regression between admission quarter and unadjusted/adjusted rates.

Point estimates for clinical models represent average slopes for the linear regression between admission quarter and the adjusted rates among the imputed datasets while standard error estimates used for 95% CIs are the combination of within- and between-imputation variance. We report the AUC (95% CI) for the first imputed dataset for the model with clinical covariates.

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eTable 11. Analyses for Area under the ROC curve (AUC)/Goodness of Fit for Claims-based and Clinical Risk-adjustment Models

		Adjustment Variables	Heart Failure	Pneumonia	Pneumonia [excluding sepsis/RF]
No indicator variables for VAMC	AUC	Adjusted for Age, Sex and Claims-Based Conditions	0.677 (0.671, 0.682)	0.697 (0.693, 0.702)	0.713 (0.707, 0.718)
		Adjusted for Age, Sex and Clinical Conditions	0.768 (0.763, 0.773)	0.743 (0.739, 0.747)	0.740 (0.735, 0.746)
		Z (p)	33.34 (<2.2e-16)	19.21 (<2.2e-16)	9.81 (<2.2e-16)
	Goodness of Fit Statistic (*p*)	Adjusted for Age, Sex and Claims-Based Conditions	31.49 (<0.001)	170.42 (<0.001)	122.4 (<0.001)
		Adjusted for Age, Sex and Clinical Conditions	7.39 (0.496)	9.45 (0.306)	9.08 (0.336)
With indicator variables for VAMC	AUC	Adjusted for Age, Sex and Claims-Based Conditions	0.689 (0.684, 0.694)	0.709 (0.705, 0.713)	0.721 (0.716, 0.727)
		Adjusted for Age, Sex and Clinical Conditions	0.777 (0.772, 0.781)	0.750 (0.745, 0.754)	0.747 (0.741, 0.752)
		Z (p)	33.65 (<2.2e-16)	18.17 (<2.2e-16)	9.45 (<2.2e-16)
	Goodness of Fit Statistic (*p*)	Adjusted for Age, Sex and Claims-Based Conditions	14.37 (0.073)	123.46 (<0.001)	98.54 (<0.001)
		Adjusted for Age, Sex and Clinical Conditions	13.14 (0.107)	12.24 (0.141)	5.86 (0.663)

The Delong Method was used to conduct a test comparing the AUC's for the claims-based and clinical models. The alternative is that the AUC of the clinical model is greater than the AUC for the claims-based model. The Z and p-values for this test are reported.

Area under the ROC curve, as well as Hosmer-Lemeshow Goodness of Fit test results, was estimated for models that included VAMC indicator variables and models that excluded them. We report the AUC/Goodness of Fit test for the first imputed dataset for the model with clinical covariates

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eTable 12. Sensitivity Analyses for Multiple Admissions – First Admission

Adjustment Variables	Measure	Heart Failure	Pneumonia	Pneumonia [excluding Sepsis/RF]
Adjusted for Age and Sex	30-day mortality, *%*			
	First year	6.13	11.05	8.25
	Last year	5.30	10.04	5.96
	Quarterly Change (95%CI), *percentage points*	-0.038 (-0.058, -0.018)	-0.036 (-0.071, -0.001)	-0.098 (-0.134, -0.063)
	AUC	0.674 (0.667, 0.682)	0.642 (0.637, 0.648)	0.656 (0.650, 0.663)
Adjusted for Age, Sex and Claims-Based Comorbid Conditions	30-day mortality, *%*			
	First year	6.11	11.28	8.34
	Last year	5.22	9.76	5.81
	Quarterly Change (95%CI), *percentage points*	-0.041 (-0.060, -0.021)	-0.059 (-0.092, -0.027)	-0.110 (-0.147, -0.074)
	AUC	0.701 (0.694, 0.709)	0.715 (0.710, 0.720)	0.727 (0.721, 0.733)
Adjusted for Age, Sex, and Clinical Covariates	30-day mortality, *%*			
	First year	5.62	10.72	7.85
	Last year	5.73	10.65	6.53
	Quarterly Change (95%CI), *percentage points*	-0.002 (-0.022, 0.017)	-0.002 (-0.033, 0.030)	-0.058 (-0.090, -0.027)
	AUC	0.777 (0.771, 0.784)	0.754 (0.749, 0.758)	0.750 (0.744, 0.756)

Notes: First year=January 2009-December 2009; Last year=October 2014-September 2015

These analyses were conducted on a sample of our study population, where we only include the *first admission for each veteran*. The number of hospitalizations on which these analyses are based on are: 84,769 for heart failure, 105,454 for pneumonia, and 85,462 for pneumonia [excluding sepsis/RF].

Point estimates (95% CIs) for quarterly changes were calculated using the slope of the linear regression between admission quarter and unadjusted/adjusted rates.

Point estimates for clinical models represent average slopes for the linear regression between admission quarter and the adjusted rates among the imputed datasets while standard error estimates used for 95% CIs are the combination of within- and between-imputation variance. We report the AUC for the first imputed dataset for the model with clinical covariates.

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eTable 13. Sensitivity Analyses for Multiple Admissions – Random Admission

Adjustment Variables	Measure	Heart Failure	Pneumonia	Pneumonia [excluding Sepsis/RF]
Adjusted for Age and Sex	30-day mortality, *%*			
	First year	8.56	12.84	9.54
	Last year	6.43	10.41	6.18
	Quarterly Change (95%CI), *percentage points*	-0.099 (-0.128, -0.069)	-0.095 (-0.131, -0.059)	-0.145 (-0.180, -0.110)
	AUC	0.664 (0.657, 0.671)	0.642 (0.637, 0.647)	0.656 (0.650, 0.663)
Adjusted for Age, Sex and Claims-Based Comorbid Conditions	30-day mortality, *%*			
	First year	8.61	13.12	9.65
	Last year	6.32	10.09	6.03
	Quarterly Change (95%CI), *percentage points*	-0.106 (-0.136, -0.076)	-0.120 (-0.155, -0.086)	-0.157 (-0.193, -0.121)
	AUC	0.696 (0.690, 0.703)	0.716 (0.711, 0.720)	0.727 (0.721, 0.732)
Adjusted for Age, Sex, and Clinical Covariates	30-day mortality, *%*			
	First year	7.92	12.42	9.07
	Last year	6.92	11.01	6.71
	Quarterly Change (95%CI), *percentage points*	-0.056 (-0.085, -0.028)	-0.055 (-0.088, -0.022)	-0.102 (-0.135, -0.069)
	AUC	0.777 (0.771, 0.783)	0.754 (0.750, 0.759)	0.750 (0.744, 0.756)

Notes: First year=January 2009-December 2009; Last year=October 2014-September 2015

These analyses were conducted on a sample of our study population, where we only include *one random admission for each veteran*. The number of hospitalizations on which these analyses are based on are: 84,769 for heart failure, 105,454 for pneumonia, and 85,462 for pneumonia [excluding sepsis/RF].

Point estimates (95% CIs) for quarterly changes were calculated using the slope of the linear regression between admission quarter and unadjusted/adjusted rates.

Point estimates for clinical models represent average slopes for the linear regression between admission quarter and the adjusted rates among the imputed datasets while standard error estimates used for 95% CIs are the combination of within- and between-imputation variance. We report the AUC for the first imputed dataset for the model with clinical covariates.

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