Online Data Supplement

Intensive Care Unit Admission and Survival among Older Patients with Chronic Obstructive Pulmonary Disease, Heart Failure, or Myocardial Infarction

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eTable 1: International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) Codes

Diagnosis	**ICD-9-CM Codes**
COPD	491.21, 491.22, 491.8, 491.9, 492.8, 493.20, 493.21, 493.22, 496
HF	401.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.xx
AMI	410.xx
Pneumonia	480.0-480.3, 480.8, 480.9, 481, 482.0, 482.1, 482.2, 482.30-482.32, 482.39-482.41, 482.49, 482.81-482.84, 482.89, 482.9, 483.0, 483.1, 483.8, 485, 486, 487.0
Acute respiratory failure	518.81, 518.82, 518.84, 799.1
Sepsis	038.xx, 785.52, 790.7, 995.91, 995.92
Shock	458, 785.5- 785.59, 958.4, 998.0
Respiratory or cardiac arrest	427.5, 799.1
Procedures	
Invasive mechanical ventilation	96.7, 96.70, 96.71, 96.72, 93.90
Non-invasive mechanical ventilation	93.90
Cardiac catheterization	37.21, 37.22, 37.23
Cardiopulmonary resuscitation	99.60, 99.63

eTable 2: Instrument analysis

Differential distance is highly correlated with ICU admission, conditional on other covariates.

Condition	Model	F-statistic	*P* value
COPD	Linear	191.3	< 0.001
HF	Linear	224.4	< 0.001
AMI	Linear	240.4	< 0.001
Total	Linear	330.2	< 0.001

Instrumental Variable – First Stage Results

Condition	Beta	95% CI	F-statistic (1, 2675)	*P* value	Adj. R-squared
COPD	-0.018 absolute change in ICU admission probability for every 10 mile increase in differential distance	(-0.02, -0.015)	191	< 0.001	0.44
HF	-0.04 absolute change in ICU admission probability for every 10 mile increase in differential distance	(-0.05, -0.04)	224	< 0.001	0.21
AMI	-0.05 absolute change in ICU admission probability for every 10 mile increase in differential distance	(-0.05, -0.04)	240	< 0.001	0.16
Total	-0.04 absolute change in ICU admission probability for every 10 mile increase in differential distance	(-0.04, -0.03)	330	< 0.001	0.21

eTable 3: Patient characteristics by median differential distance for COPD

Characteristic	< 3.7 miles No. (%)	≥ 3.7 miles No (%)
No. Patients	302,524 (50.0)	302,371 (50.0)
ICU Patients	77,480 (25.6)	43,729 (14.5)
Age, mean (SD)	77 (8)	77 (8)
65-74 years	127,489 (42.1)	128,552 (42.5)
75-84 years	114,750 (37.9)	115,597 (38.2)
≥ 85 years	60,285 (19.9)	58,222 (19.3)
Female	178,477 (59.0)	176,061 (58.2)
Race/Ethnicity		
White	254,753 (84.2)	276,956 (91.6)
Black	33,990 (11.2)	18,551 (6.1)
Other	13781 (4.6)	6864 (2.2)
Urbanicity		
Large Central Metropolitan	90,869 (30.0)	19,860 (6.6)
Large Suburban Metropolitan	70,578 (23.3)	74,738 (24.7)
Medium Metropolitan	64,558 (21.3)	64,550 (21.4)
Small Metropolitan	28,927 (9.6)	52,060 (17.2)
Micropolitan	28,111 (9.3)	55,681 (18.4)
Noncore	19,481 (6.4)	35,482 (11.7)
Median Household Income by Zip Code		
< $40,000	83,983 (27.8)	91,648 (30.3)
$40,000-$100,000	204,028 (67.4)	198,324 (65.6)
≥ $100,000	14,513 (4.8)	12,399 (4.1)
Elixhauser Comorbidities, mean (SD)	2.6 (1.2)	2.6 (1.2)
Admission Source		
Outpatient	17,154 (5.7)	20,850 (6.9)
Emergency Department	284,452 (94.3)	280,397 (93.1)
Angus Organ Failure Score[a]		
0	236,611 (78.2)	248,008 (82.0)
1	50,695 (16.8)	43,569 (14.4)
≥ 2	15218 (5)	10794 (3.6)
Year of Admission		

2010	105,365 (50.8)	102,188 (49.2)
2011	104,426 (50.0)	104,350 (50.0)
2012	92,733 (49.2)	95,833 (50.8)

[a] Angus organ failure score, which identifies severity of illness by patient organ failures derived from the administrative record with a maximum score of six. Higher scores indicate more organ failures.

eTable 4: Patient characteristics by median differential distance for HF

Characteristic	< 4.8 miles No. (%)	≥ 4.8 miles No (%)
No. Patients	313,075 (50.0)	313,099 (50.0)
ICU Patients	107,120 (34.2)	47,325 (15.1)
Age, mean (SD)	80 (8)	80 (8)
65-74 years	87,698 (28.0)	83,072 (26.5)
75-84 years	108,416 (34.6)	110,521 (35.3)
≥ 85 years	116,961 (37.4)	119,506 (38.2)
Female	173,391 (55.4)	174,558 (55.8)
Race/Ethnicity		
White	252,646 (80.7)	272,066 (86.9)
Black	44,549 (14.2)	32,196 (10.3)
Other	15,880 (5.1)	8,837 (2.8)
Urbanicity		
Large Central Metropolitan	98,701 (31.5)	26,728 (8.5)
Large Suburban Metropolitan	78,475 (25.1)	71,605 (22.9)
Medium Metropolitan	63,568 (20.3)	76,723 (24.5)
Small Metropolitan	27,319 (8.7)	50,957 (16.3)
Micropolitan	25,549 (8.2)	55,229 (17.6)
Noncore	19,463 (6.2)	31,857 (10.2)
Median Household Income by Zip Code		
< $40,000	81,549 (26.1)	89,818 (28.7)
$40,000-$100,000	211,627 (67.6)	210,204 (67.1)
≥ $100,000	19,899 (6.4)	13,077 (4.2)
Elixhauser Comorbidities, mean (SD)	3.1 (1.0)	3.2 (1.0)
Admission Source		
Outpatient	19,277 (6.2)	24,175 (7.8)
Emergency Department	292,906 (93.8)	287,698 (92.2)
Angus Organ Failure Score[a]		
0	218,743 (69.9)	230,060 (73.5)
1	78,595 (25.1)	71,825 (22.9)
≥ 2	15737 (4.9)	11214 (3.6)

Year of Admission		
2010	110,623 (50.2)	109,623 (49.8)
2011	105,651 (50.0)	105,738 (50.0)
2012	96,801 (49.8)	97,738 (50.2)

[a] Angus organ failure score, which identifies severity of illness by patient organ failures derived from the administrative record with a maximum score of six. Higher scores indicate more organ failures.

eTable 5: Patient characteristics by median differential distance for AMI

Characteristic	< 3.3 miles No. (%)	≥ 3.3 miles No (%)
No. Patients	162,545 (50.1)	162,184 (49.9)
ICU Patients	124,269 (76.5)	86,349 (53.2)
Age, mean (SD)	78 (8)	78 (8)
65-74 years	62,688 (38.6)	59,082 (36.4)
75-84 years	55,765 (34.3)	55,696 (34.3)
≥ 85 years	44,092 (27.1)	47,406 (29.2)
Female	77,847 (47.9)	78,865 (48.6)
Race/Ethnicity		
White	136,915 (84.2)	145,725 (89.9)
Black	16,277 (10.0)	11,298 (7.0)
Other	9,353 (5.8)	5,161 (3.2)
Urbanicity		
Large Central Metropolitan	51,011 (31.4)	14,850 (9.2)
Large Suburban Metropolitan	39,905 (24.6)	35,639 (22.0)
Medium Metropolitan	33,178 (20.4)	39,853 (24.6)
Small Metropolitan	16,750 (10.3)	26,180 (16.1)
Micropolitan	11,953 (7.4)	27,847 (17.2)
Noncore	9,748 (6.0)	17,815 (11.0)
Median Household Income by Zip Code		
< $40,000	38,482 (23.7)	44,237 (27.3)
$40,000-$100,000	113,919 (70.1)	110,561 (68.2)
≥ $100,000	10,144 (6.2)	7,386 (4.6)
Elixhauser Comorbidities, mean (SD)	2.5 (1.2)	2.5 (1.2)
Admission Source		
Outpatient	6,253 (3.9)	8,858 (5.5)
Emergency Department	155,621 (96.1)	152,420 (94.5)
Angus Organ Failure Score[a]		
0	103,392 (63.6)	111,149 (68.5)
1	40,576 (25.0)	37,313 (23.0)
≥ 2	18577 (11.5)	13722 (8.5)
Year of Admission		
2010	56,324 (50.1)	56,127 (49.9)
2011	54,082 (50.0)	53,965 (50.0)

2012	52,139 (50.0)	52,092 (50.0)

[a] Angus organ failure score, which identifies severity of illness by patient organ failures derived from the administrative record with a maximum score of six. Higher scores indicate more organ failures.

eTable 6: Hospital characteristics by quintile of ICU admission rates for COPD

Characteristics	Quintile 1 (<12%)	Quintile 2 (12-17%)	Quintile 3 (18-23%)	Quintile 4 (24-32%)	Quintile 5 (>32%)
No. Hospitals	539 (20.0)	539 (20.0)	538 (20.0)	539 (20.0)	538 (20.0)
Hospital Ownership					
For-profit	89 (16.64)	103 (19.22)	105 (19.59)	106 (19.81)	125 (23.41)
Not-for-profit	378 (70.65)	363 (67.72)	347 (64.74)	331 (61.87)	324 (60.67)
Government	68 (12.71)	70 (13.06)	84 (15.67)	98 (18.32)	85 (15.92)
Medical School Affiliation	190 (35.25)	149 (27.64)	177 (32.9)	204 (37.85)	209 (38.85)
Teaching Status					
No Residents	428 (79.55)	437 (81.08)	432 (80.3)	425 (78.85)	433 (80.48)
Minor Teaching Program (< 0.25 residents/bed)	64 (11.9)	73 (13.54)	73 (13.57)	73 (13.54)	62 (11.52)
Major Teaching Program (≥ 0.25 residents/bed)	46 (8.55)	29 (5.38)	33 (6.13)	41 (7.61)	43 (7.99)
Hospital Beds					
< 100	144 (26.77)	157 (29.13)	130 (24.16)	127 (23.56)	115 (21.38)
100-199	167 (31.04)	135 (25.05)	164 (30.48)	154 (28.57)	161 (29.93)
≥ 200	227 (42.19)	247 (45.83)	244 (45.35)	258 (47.87)	262 (48.7)
Percent of ICU Beds					
≤ 5%	53 (9.85)	28 (5.19)	46 (8.55)	23 (4.27)	23 (4.28)
5-10%	299 (55.58)	276 (51.21)	221 (41.08)	203 (37.66)	185 (34.39)
> 10%	186 (34.57)	235 (43.6)	271 (50.37)	313 (58.07)	330 (61.34)
Hospital COPD Annual Case Volume, Mean (SD)	129 (111)	124 (82)	107 (84)	83 (63)	69 (59)
Nursing FTE[a] per 1000 Patient-Days, Mean (SD)	3.6 (1.6)	3.7 (1.3)	3.8 (1.7)	4.0 (1.7)	4.2 (1.7)
Technology Index, Mean (SD)[b]	23.4 (11.6)	23.7 (11.5)	24.3 (11.9)	25.4 (12.5)	25.6 (12.6)
Medicaid Patients					
< 7%	228 (42.38)	231 (42.86)	191 (35.5)	175 (32.47)	160 (29.74)
7-11%	183	172	185	162	155

	(34.01)	(31.91)	(34.39)	(30.06)	(28.81)
> 11%	127 (23.61)	136 (25.23)	162 (30.11)	202 (37.48)	223 (41.45)
Census Regions					
Northeast	143 (27.24)	91 (16.88)	89 (16.54)	60 (11.15)	63 (11.75)
Midwest	187 (35.62)	197 (36.55)	190 (35.32)	185 (34.39)	169 (31.53)
South	131 (24.95)	179 (33.21)	173 (32.16)	180 (33.46)	151 (28.17)
West	64 (12.19)	72 (13.36)	86 (15.99)	113 (21)	153 (28.54)

[a] Full-time equivalents over the entire hospital

[b] Weighted sum of hospital capabilities, including obstetrics, ICU care, emergency department, trauma center, open heart surgery, radiation therapy, CT, diagnostic radiology, magnetic resonance imaging, positron-emission tomography, single-photon emission CT, ultrasonography, and transplantation service

eTable 7: Hospital characteristics by quintile of ICU admission rates for HF

Characteristics	**Quintile 1 (<12%)**	**Quintile 2 (12-18%)**	**Quintile 3 (19-31%)**	**Quintile 4 (32-55%)**	**Quintile 5 (>55%)**
No. Hospitals	538 (20.0)	538 (20.0)	538 (20.0)	538 (20.0)	538 (20.0)
Hospital Ownership					
For-profit	75 (13.99)	82 (15.36)	119 (22.16)	120 (22.51)	131 (24.49)
Not-for-profit	394 (73.51)	360 (67.42)	324 (60.34)	323 (60.6)	340 (63.55)
Government	67 (12.5)	92 (17.23)	94 (17.5)	90 (16.89)	64 (11.96)
Medical School Affiliation	223 (41.45)	173 (32.16)	147 (27.32)	190 (35.32)	193 (35.87)
Teaching Status					
No Residents	401 (74.67)	432 (80.3)	457 (84.94)	415 (77.14)	448 (83.27)
Minor Teaching Program (< 0.25 residents/bed)	82 (15.27)	67 (12.45)	50 (9.29)	82 (15.24)	63 (11.71)
Major Teaching Program (≥ 0.25 residents/bed)	54 (10.06)	39 (7.25)	31 (5.76)	41 (7.62)	27 (5.02)
Hospital Beds					
< 100	120 (22.35)	138 (25.65)	179 (33.27)	141 (26.21)	94 (17.47)
100-199	139 (25.88)	141 (26.21)	172 (31.97)	144 (26.77)	183 (34.01)
≥ 200	278 (51.77)	259 (48.14)	187 (34.76)	253 (47.03)	261 (48.51)
Percent of Total that are ICU Beds					
≤ 5%	39 (7.26)	44 (8.18)	40 (7.43)	25 (4.65)	24 (4.46)
5-10%	299 (55.68)	247 (45.91)	218 (40.52)	222 (41.26)	198 (36.8)
> 10%	199 (37.06)	247 (45.91)	280 (52.04)	291 (54.09)	316 (58.74)
Hospital HF Annual Case Volume, Mean (SD)	166 (149)	140 (107)	91 (89)	59 (64)	64 (75)
Nursing FTE[a] per 1000 Patient-Days, Mean (SD)	3.9 (1.9)	3.8 (1.6)	3.7 (1.4)	3.9 (1.5)	4.1 (1.5)
Technology Index, Mean (SD)[b]	25.2 (12.0)	24.2 (11.9)	23.1 (11.8)	25.0 (12.4)	25.0 (12.0)
Medicaid Patients					
< 7%	210 (39.11)	212 (39.41)	208 (38.66)	193 (35.87)	161 (29.93)

7-11%	198 (36.87)	177 (32.9)	170 (31.6)	151 (28.07)	161 (29.93)
> 11%	129 (24.02)	149 (27.7)	160 (29.74)	194 (36.06)	216 (40.15)
Census Regions					
Northeast	131 (24.76)	94 (17.47)	76 (14.15)	72 (13.38)	73 (13.7)
Midwest	187 (35.35)	192 (35.69)	184 (34.26)	190 (35.32)	175 (32.83)
South	129 (24.39)	183 (34.01)	185 (34.45)	183 (34.01)	134 (25.14)
West	82 (15.5)	69 (12.83)	92 (17.13)	93 (17.29)	151 (28.33)

[a] Full-time equivalents over the entire hospital

[b] Weighted sum of hospital capabilities, including obstetrics, ICU care, emergency department, trauma center, open heart surgery, radiation therapy, CT, diagnostic radiology, magnetic resonance imaging, positron-emission tomography, single-photon emission CT, ultrasonography, and transplantation service

eTable 8: Hospital characteristics by quintile of ICU admission rates for AMI

Characteristics	Quintile 1 (<43%)	Quintile 2 (43-61%)	Quintile 3 (62-80%)	Quintile 4 (81-94%)	Quintile 5 (>94%)
No. Hospitals	535 (20.0)	536 (20.1)	532 (19.9)	534 (20.0)	534 (20.0)
Hospital Ownership					
For-profit	64 (12.01)	94 (17.64)	121 (23.05)	118 (22.14)	123 (23.12)
Not-for-profit	394 (73.92)	348 (65.29)	308 (58.67)	335 (62.85)	351 (65.98)
Government	75 (14.07)	91 (17.07)	96 (18.29)	80 (15.01)	58 (10.9)
Medical School Affiliation	169 (31.59)	174 (32.46)	165 (31.02)	201 (37.64)	212 (39.7)
Teaching Status					
No Residents	435 (81.46)	441 (82.28)	427 (80.26)	407 (76.22)	422 (79.03)
Minor Teaching Program (< 0.25 residents/bed)	57 (10.67)	63 (11.75)	66 (12.41)	81 (15.17)	79 (14.79)
Major Teaching Program (≥ 0.25 residents/bed)	42 (7.87)	32 (5.97)	39 (7.33)	46 (8.61)	33 (6.18)
Hospital Beds					
< 100	197 (36.89)	157 (29.29)	141 (26.5)	98 (18.35)	66 (12.36)
100-199	134 (25.09)	147 (27.43)	167 (31.39)	163 (30.52)	164 (30.71)
≥ 200	203 (38.01)	232 (43.28)	224 (42.11)	273 (51.12)	304 (56.93)
Percent of Total that are ICU Beds					
≤ 5%	51 (9.55)	37 (6.9)	38 (7.14)	21 (3.93)	22 (4.12)
5-10%	280 (52.43)	245 (45.71)	231 (43.42)	217 (40.64)	206 (38.58)
> 10%	203 (38.01)	254 (47.39)	263 (49.44)	296 (55.43)	306 (57.3)
Hospital MI Annual Case Volume, Mean (SD)	52 (58)	55 (55)	44 (46)	39 (35)	41 (37)
Nursing FTE[a] per 1000 Patient-Days, Mean (SD)	3.7 (1.6)	3.8 (1.7)	3.8 (1.5)	4.0 (1.4)	4.2 (1.6)
Technology Index, Mean (SD)[b]	21.7 (11.4)	23.9 (12.2)	23.5 (11.7)	26.6 (12.1)	27.0 (11.9)
Medicaid Patients					
< 7%	245 (45.88)	203 (37.87)	199 (37.41)	172 (32.21)	154 (28.84)

7-11%	187 (35.02)	177 (33.02)	178 (33.46)	163 (30.52)	150 (28.09)
> 11%	102 (19.1)	156 (29.1)	155 (29.14)	199 (37.27)	230 (43.07)
Census Regions					
Northeast	138 (26.04)	83 (15.6)	71 (13.4)	76 (14.23)	78 (14.72)
Midwest	192 (36.23)	187 (35.15)	187 (35.28)	203 (38.01)	157 (29.62)
South	122 (23.02)	199 (37.41)	194 (36.6)	154 (28.84)	135 (25.47)
West	78 (14.72)	63 (11.84)	78 (14.72)	101 (18.91)	160 (30.19)

[a] Full-time equivalents over the entire hospital

[b] Weighted sum of hospital capabilities, including obstetrics, ICU care, emergency department, trauma center, open heart surgery, radiation therapy, CT, diagnostic radiology, magnetic resonance imaging, positron-emission tomography, single-photon emission CT, ultrasonography, and transplantation service

eTable 9: Multivariable regression results[a]

COPD		
Model	**Absolute Difference (95% CI)**	***P* value**
30-day mortality	3.7% (3.4, 4.1)	< 0.001
Hospital costs	$5,020 (4741, 5298)	< 0.001
HF		
Model	**Absolute Difference (95% CI)**	***P* value**
30-day mortality	1.8% (1.5, 2.1)	< 0.001
Hospital costs	$5,764 (5373, 6156)	< 0.001
AMI		
Model	**Absolute Difference (95% CI)**	***P* value**
30-day mortality	-1.8% (-2.1, -1.5)	< 0.001
Hospital costs	$8,117 (7781, 8453)	< 0.001

[a] Model adjusted for all variables in tables 1 and 2 in addition to all 29 individual Elixhauser comorbidities. Angus organ failure score, which identifies severity of illness by patient organ failures derived from the administrative record with a maximum score of six, was defined to include all organ failures numbered 0 to $\underline{\geq}$ 5. Higher scores indicate more organ failures. Hospital region included the nine U.S. census defined regions. All standard errors for models were adjusted for clustering of patients within hospitals.

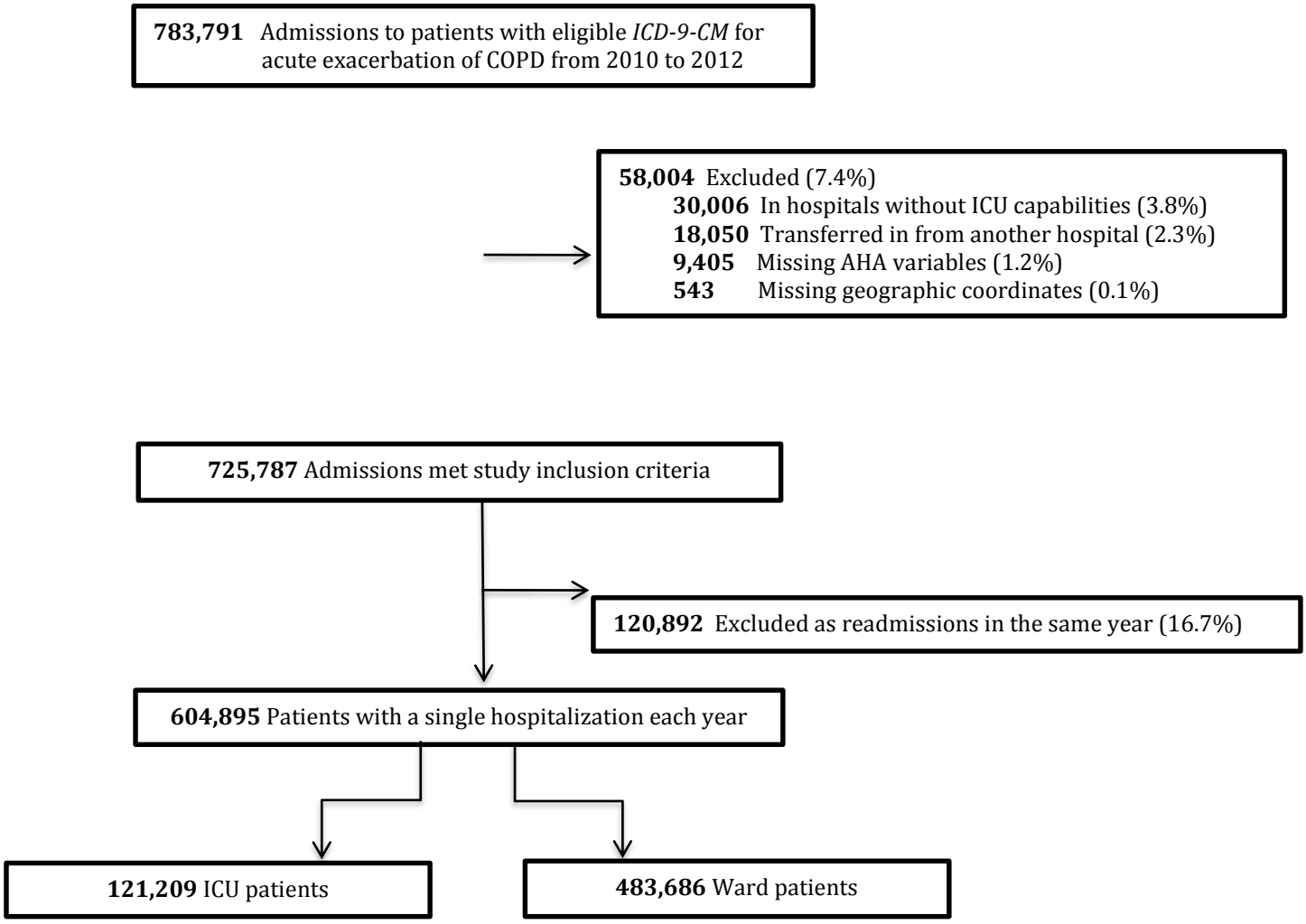
eTable 10: Sensitivity analysis[a,b]

HF (n=708,758)		
Model	**Absolute Difference (95% CI)**	***P* value**
30-day mortality	1.3% (-0.4, 3.1)	0.14
Hospital costs	$2,537 (997,4076)	0.001

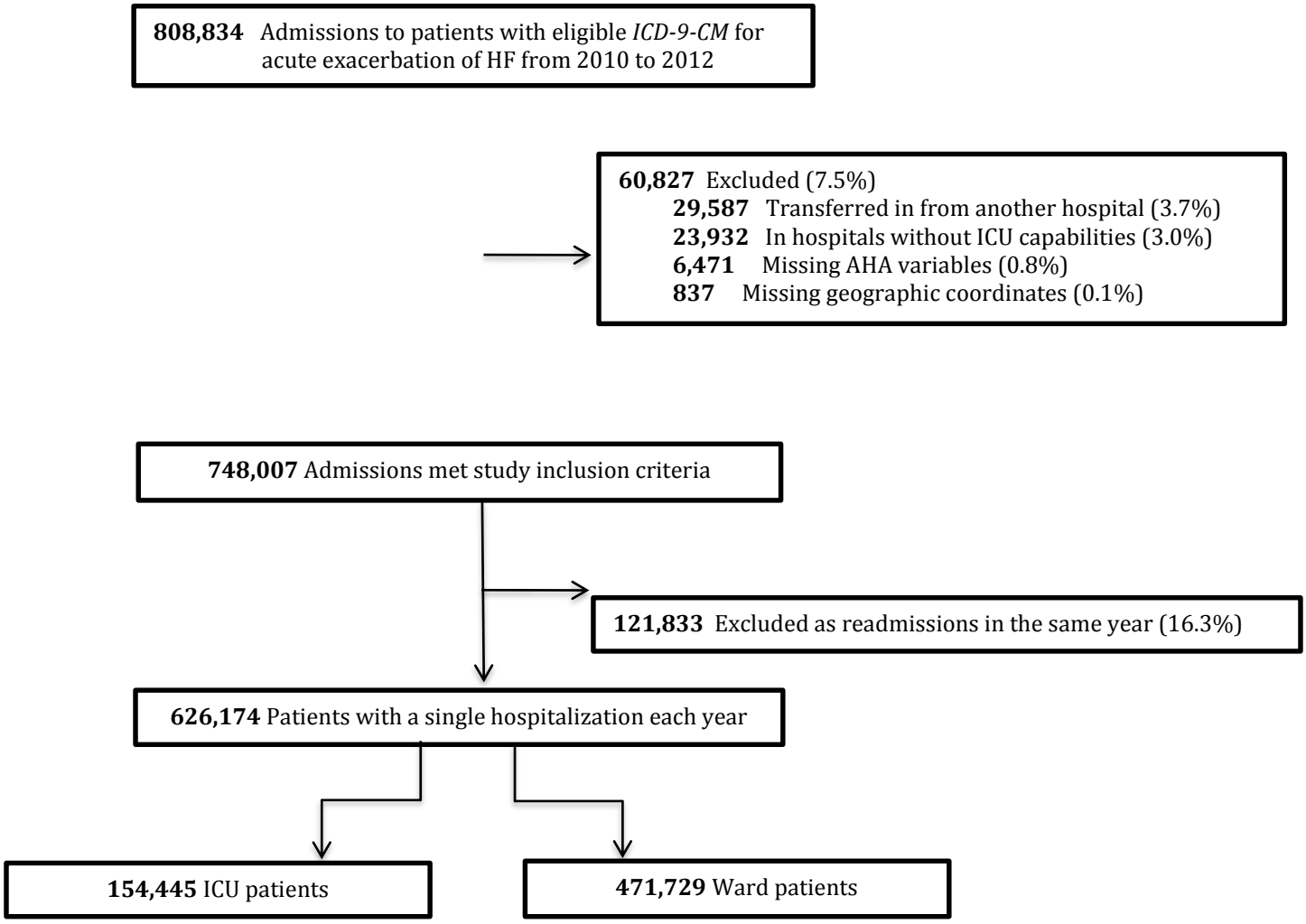
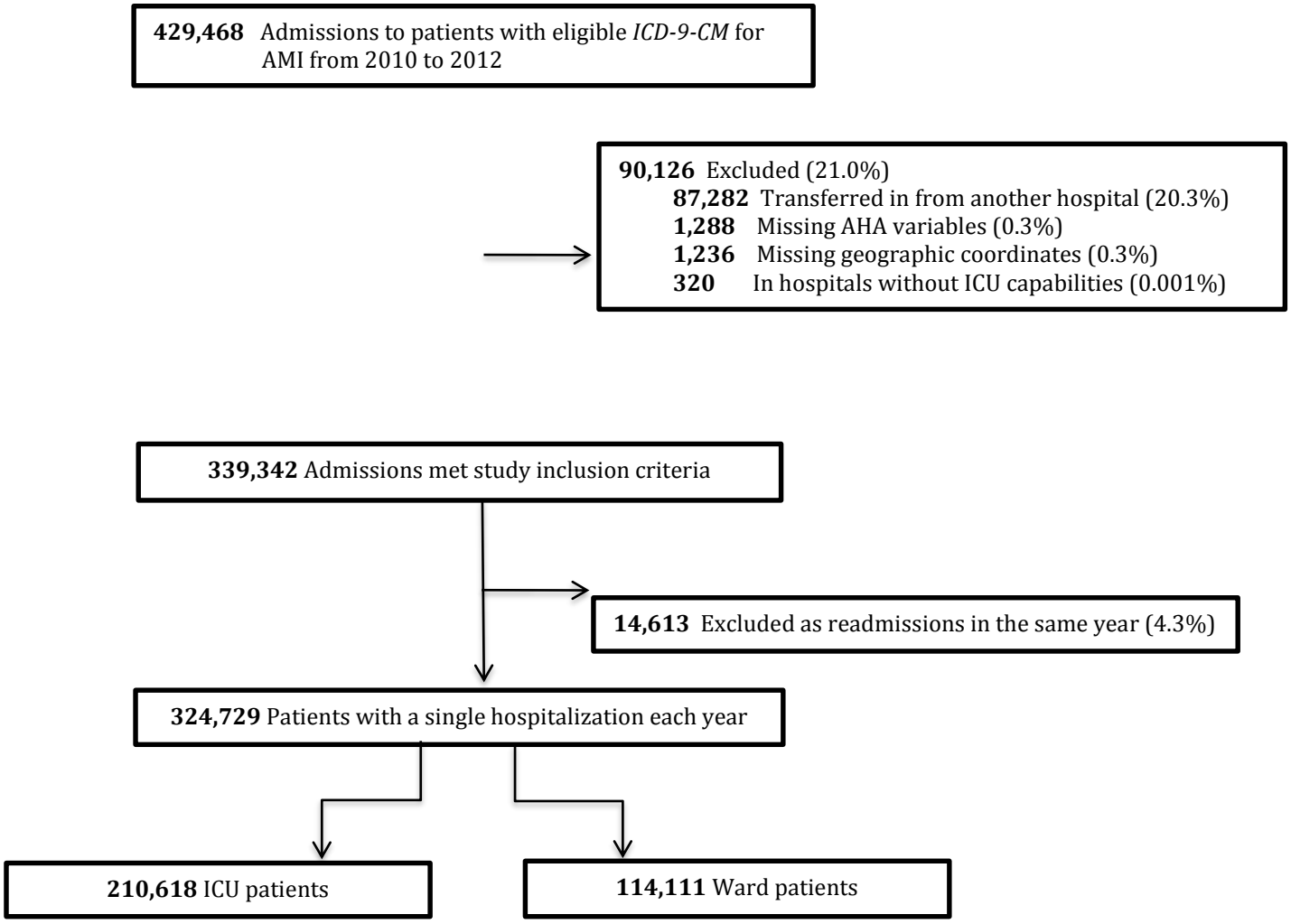
[a] Model adjusted for all variables in tables 1 and 2 in addition to all 29 individual Elixhauser comorbidities. Angus organ failure score, which identifies severity of illness by patient organ failures derived from the administrative record with a maximum score of six, was defined to include all organ failures numbered 0 to $\geq$ 5. Higher scores indicate more organ failures. Hospital region included the nine U.S. census defined regions. All standard errors for models were adjusted for clustering of patients within hospitals.

[b] 2-stage least squared regression of all patients using differential distance to nearest high-ICU use hospital as instrumental variable, adjusted for all variables in tables 1 and 2, and for clustering of patients within hospitals

eFigure 1: Study selection criteria/recruitment table for COPD



eFigure 2: Study selection criteria/recruitment table for HF



eFigure 3: Study selection criteria/recruitment table for AMI