

Supplementary Online Content

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

eMethods. Additional Description of Study Methods

Event study framework

We estimate the period-specific effect of each year relative to acquisition for hospitals acquired by private equity firms the following specification:

$$Y_{ijt} = PE_j \sum_{\substack{s=-6 \\ s \neq -1}}^6 \gamma_s 1\{t - t_j^* = s\} + X_{ijt}\beta + \mu_j + \delta_{m(j)t} + \epsilon_{ijt}$$

In this instance, Y_{ijt} is the outcome measure for a given patient i at hospital j in year t . The indicators $1\{t - t_j^* = s\}$ reflect the time relative to the acquisition year t_j^* , and are zeroes in all years for hospitals that are not acquired by a private equity firm. Data from years greater than five years relative to the year of acquisition (i.e., $|s| \geq 6$), are grouped into a single indicator. The parameter γ_s is the pre- or post-treatment period coefficient. The coefficients for the pre-treatment periods (here given by $\gamma_{-6}, \gamma_{-5}, \gamma_{-4}, \gamma_{-3}$, and γ_{-2}) can be visually examined for parallel trends and formally tested for equality. All years of data were kept in the event-study sample, and the year prior to PE acquisition (i.e., $s = -1$), is the omitted category.

The second term (including the parameter vector β), includes a vector of patient-level controls, X_{ijt} , which include patient age, Elixhauser comorbidity index, and indicators for race, sex, admission and entitlement type, and an indicator for any hospitalization in the past year. Hospital fixed effects (μ_j) and market (hospital service area [HSA]) by year fixed effects $\delta_{m(j)t}$, control for time-invariant hospital-specific unobservables and market-specific time trends, respectively. Standard errors are clustered at the hospital level.

Difference-in-differences analysis

We estimate the reduced-form effect of private equity acquisition on patient outcomes using the following difference-in-differences specification:

$$Y_{ijt} = \gamma(PE_j \times Post_t) + X_{ijt}\beta + \mu_j + \delta_{m(j)t} + \epsilon_{ijt}$$

As before, Y_{ijt} is the outcome measure for a given patient i at hospital j in year t . PE_j is an indicator for the exposure of interest (private equity acquisition) that takes a value of 1 for hospitals which are acquired by a private equity firm, and $Post_t$ is an indicator that takes a value of 1 in each year following the acquisition. The parameter γ is the difference-in-differences estimator, which quantifies the effect of private equity acquisition. As above in the event study framework, the second term in the estimating equation (which estimates the parameter vector β), includes a vector of patient-level controls, X_{ijt} . Hospital fixed effects (μ_j) and market (hospital service area [HSA]) by year fixed effects $\delta_{m(j)t}$, control for time-invariant hospital-specific unobservables and market-specific time trends, respectively. Standard errors are clustered at the hospital level.

All hospitals acquired between 2001 and 2018 are included in the potential treatment group. Observations within three years prior to and following the acquisition were included. Observations from the acquisition year were excluded. All observations from all years of the study period for all potential control hospitals were included. The full sample was restricted to hospitals defined as short-term acute care hospitals (American Hospital Association service code ("SERV" variable) 10), excluding hospitals with a critical access designation.

eTable 1. Primary Diagnosis Codes

	Format	Codes
Acute myocardial infarction	ICD-9-CM	410.00, 410.01, 410.10, 410.11, 410.20, 410.21, 410.30, 410.31, 410.40, 410.41, 410.50, 410.51, 410.60, 410.61, 410.70, 410.71, 410.80, 410.81, 410.90, 410.91
	ICD-10	I21.11, I21.19, I21.21, I21.29, I21.3, I21.4, I22.1, I22.2, I22.29, I22.8, I22.9
Congestive Heart Failure	ICD-9-CM	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, 428.9
	ICD-10-CM	I50.1, I50.20, I50.21, I50.30, I50.31, I50.32, I50.33, I50.40, I50.41, I50.42, I50.43, I50.9
Acute Stroke	ICD-9-CM	433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91
	ICD-10-CM	I63.00, I63.011, I63.012, I63.013, I63.019, I63.02, I63.031, I63.032, I63.033, I63.039, I63.09, I63.10, I63.111, I63.112, I63.113, I63.119, I63.12, I63.131, I63.132, I63.133, I63.139, I63.19, I63.20, I63.211, I63.212, I63.213, I63.219, I63.22, I63.231, I63.232, I63.233, I63.239, I63.29, I63.30, I63.311, I63.312, I63.313, I63.319, I63.321, I63.322, I63.323, I63.329, I63.331, I63.332, I63.333, I63.339, I63.341, I63.342, I63.343, I63.349, I63.39, I63.40, I63.411, I63.412, I63.413, I63.419, I63.421, I63.422, I63.423, I63.429, I63.431, I63.432, I63.433, I63.439, I63.441, I63.442, I63.443, I63.449, I63.49, I63.50, I63.511, I63.512, I63.513, I63.519, I63.521, I63.522, I63.523, I63.529, I63.531, I63.532, I63.533, I63.539, I63.541, I63.542, I63.543, I63.549, I63.59, I63.6, I63.81, I63.89, I63.9
Pneumonia	ICD-9-CM	481, 482.0, 482.1, 482.2, 482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.42, 482.49, 482.82, 482.83, 482.84, 482.89, 482.9, 483.1, 483.8, 485, 486
	ICD-10-CM	A481, J14, J15.20, J15.211, J15.212, J15.29, J15.4, J15.5, J15.6, J15.7, J15.8, J15.9, J16.0, J16.8, J18.0, J18.8, J18.9
Chronic obstructive pulmonary disease	ICD-9-CM	490, 491.0, 491.1, 491.2, 491.20, 491.21, 491.22, 491.8, 491.9, 492.0, 492.8, 494, 494.0, 494.1, 496
	ICD-10-CM	J40, J41.0, J41.1, J41.8, J42, J43.0, J43.1, J43.2, J43.8, J43.9, J44.0, J44.1, J44.9, J47.0, J47.1, J47.9

eTable 2. Patient-Level Summary Statistics Across Conditions at the Beginning and End of the Study Period

	AMI		CHF		Stroke		PNA		COPD	
	2001	2018	2001	2018	2001	2018	2001	2018	2001	2018
Elixhauser Comorbidity Index	1.352	1.702	2.301	2.831	1.254	1.606	1.276	2.042	2.158	2.967
	(2.233)	(2.994)	(2.895)	(3.656)	(2.112)	(2.845)	(2.214)	(3.176)	(2.528)	(3.572)
Length of stay, (days)	6.125	4.404	5.586	4.724	6.415	4.313	6.576	4.757	5.376	4.168
	(5.306)	(4.373)	(4.652)	(3.734)	(5.132)	(3.969)	(5.114)	(3.607)	(4.192)	(3.178)
In-hospital mortality	0.129	0.0585	0.0559	0.0358	0.0806	0.0426	0.0899	0.0312	0.0364	0.0129
	(0.335)	(0.235)	(0.230)	(0.186)	(0.272)	(0.202)	(0.286)	(0.174)	(0.187)	(0.113)
30-day mortality	0.190	0.118	0.114	0.132	0.157	0.136	0.157	0.107	0.0816	0.0534
	(0.392)	(0.323)	(0.318)	(0.338)	(0.364)	(0.343)	(0.364)	(0.309)	(0.274)	(0.225)
30-day readmission	0.192	0.161	0.174	0.179	0.148	0.131	0.112	0.142	0.192	0.178
	(0.394)	(0.367)	(0.379)	(0.384)	(0.355)	(0.337)	(0.315)	(0.349)	(0.394)	(0.383)
Medicare spending: 30-day	12069	27696	6306	25044	9469	23960	4961	24346	5823	15790
	(14430)	(25256)	(10348)	(25159)	(10938)	(21553)	(9798)	(23670)	(8075)	(15331)
Age at admission, (years)	78.95	77.85	79.93	81.25	79.35	79.62	80.41	80.11	76.70	76.86
	(7.643)	(8.278)	(7.654)	(8.669)	(7.438)	(8.486)	(7.874)	(8.512)	(6.864)	(7.502)
Proportion male	0.481	0.556	0.402	0.431	0.396	0.449	0.452	0.455	0.435	0.419
	(0.500)	(0.497)	(0.490)	(0.495)	(0.489)	(0.497)	(0.498)	(0.498)	(0.496)	(0.493)
Proportion white	0.891	0.848	0.843	0.896	0.841	0.819	0.879	0.865	0.892	0.858
	(0.312)	(0.359)	(0.364)	(0.305)	(0.366)	(0.385)	(0.326)	(0.342)	(0.310)	(0.349)
Proportion black	0.0757	0.0845	0.120	0.0630	0.122	0.117	0.0828	0.0782	0.0779	0.0981
	(0.265)	(0.278)	(0.325)	(0.243)	(0.328)	(0.322)	(0.276)	(0.268)	(0.268)	(0.297)
Proportion admitted in preceding year	0.341	0.282	0.472	0.436	0.346	0.290	0.325	0.352	0.539	0.491
	(0.474)	(0.450)	(0.499)	(0.496)	(0.476)	(0.454)	(0.468)	(0.477)	(0.498)	(0.500)

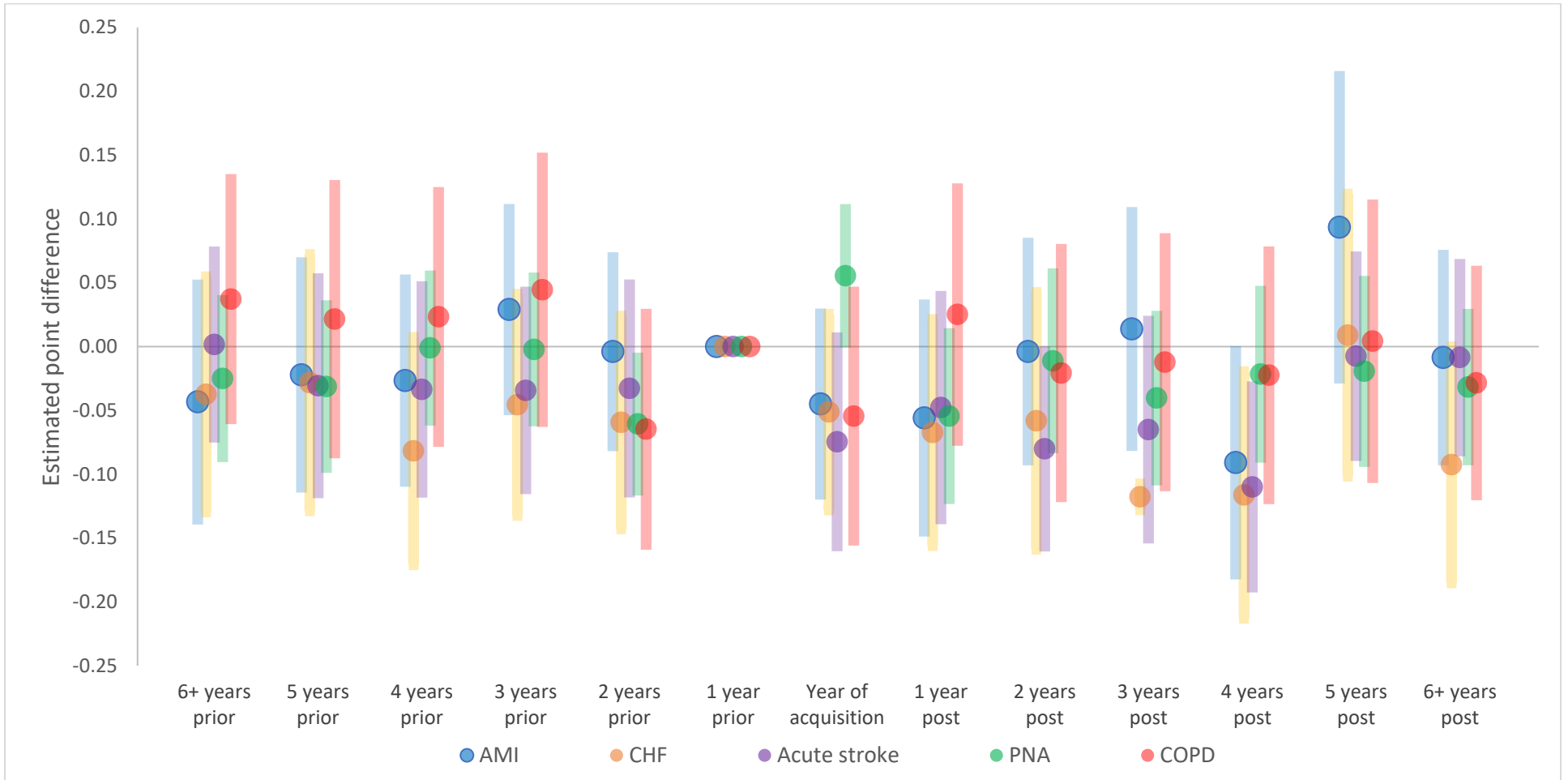
*Values are means and standard deviations.

eTable 3. Distribution of Patients by Treating Hospital Characteristics Across Conditions at the Beginning and End of the Study Period

	AMI		CHF		Stroke		PNA		COPD	
	2001	2018	2001	2018	2001	2018	2001	2018	2001	2018
Total beds*	364.6	417.3	362.2	352.3	382.3	456.4	332.3	368.2	334.1	365.4
	(260.4)	(319.3)	(267.1)	(305.2)	(270.3)	(345.9)	(255.6)	(319.4)	(250.9)	(309.5)
Proportion that are non-profit	0.772	0.729	0.761	0.740	0.775	0.743	0.748	0.719	0.735	0.715
	(0.420)	(0.445)	(0.426)	(0.439)	(0.417)	(0.437)	(0.434)	(0.449)	(0.441)	(0.451)
Proportion that are for profit	0.101	0.161	0.110	0.112	0.0979	0.132	0.113	0.153	0.121	0.158
	(0.301)	(0.367)	(0.313)	(0.315)	(0.297)	(0.339)	(0.316)	(0.360)	(0.326)	(0.365)
Proportion that are government-run	0.127	0.111	0.128	0.148	0.127	0.125	0.139	0.127	0.144	0.127
	(0.333)	(0.314)	(0.335)	(0.355)	(0.333)	(0.331)	(0.346)	(0.333)	(0.351)	(0.333)
Proportion that are major teaching hospitals	0.376	0.431	0.367	0.352	0.379	0.430	0.341	0.381	0.340	0.372
	(0.484)	(0.495)	(0.482)	(0.477)	(0.485)	(0.495)	(0.474)	(0.486)	(0.474)	(0.483)
Proportion that are minor teaching hospitals	0.0847	0.158	0.0925	0.150	0.102	0.193	0.0773	0.120	0.0699	0.136
	(0.278)	(0.365)	(0.290)	(0.357)	(0.303)	(0.395)	(0.267)	(0.325)	(0.255)	(0.343)
Proportion with a core-based statistical area designated "metropolitan"	0.844	0.904	0.843	0.823	0.868	0.919	0.807	0.846	0.808	0.844
	(0.362)	(0.295)	(0.363)	(0.382)	(0.338)	(0.273)	(0.395)	(0.361)	(0.394)	(0.363)
Proportion with a core-based statistical area designated "micropolitan"	0.123	0.0855	0.118	0.142	0.107	0.0703	0.144	0.124	0.142	0.123
	(0.328)	(0.280)	(0.323)	(0.349)	(0.309)	(0.256)	(0.351)	(0.329)	(0.349)	(0.329)

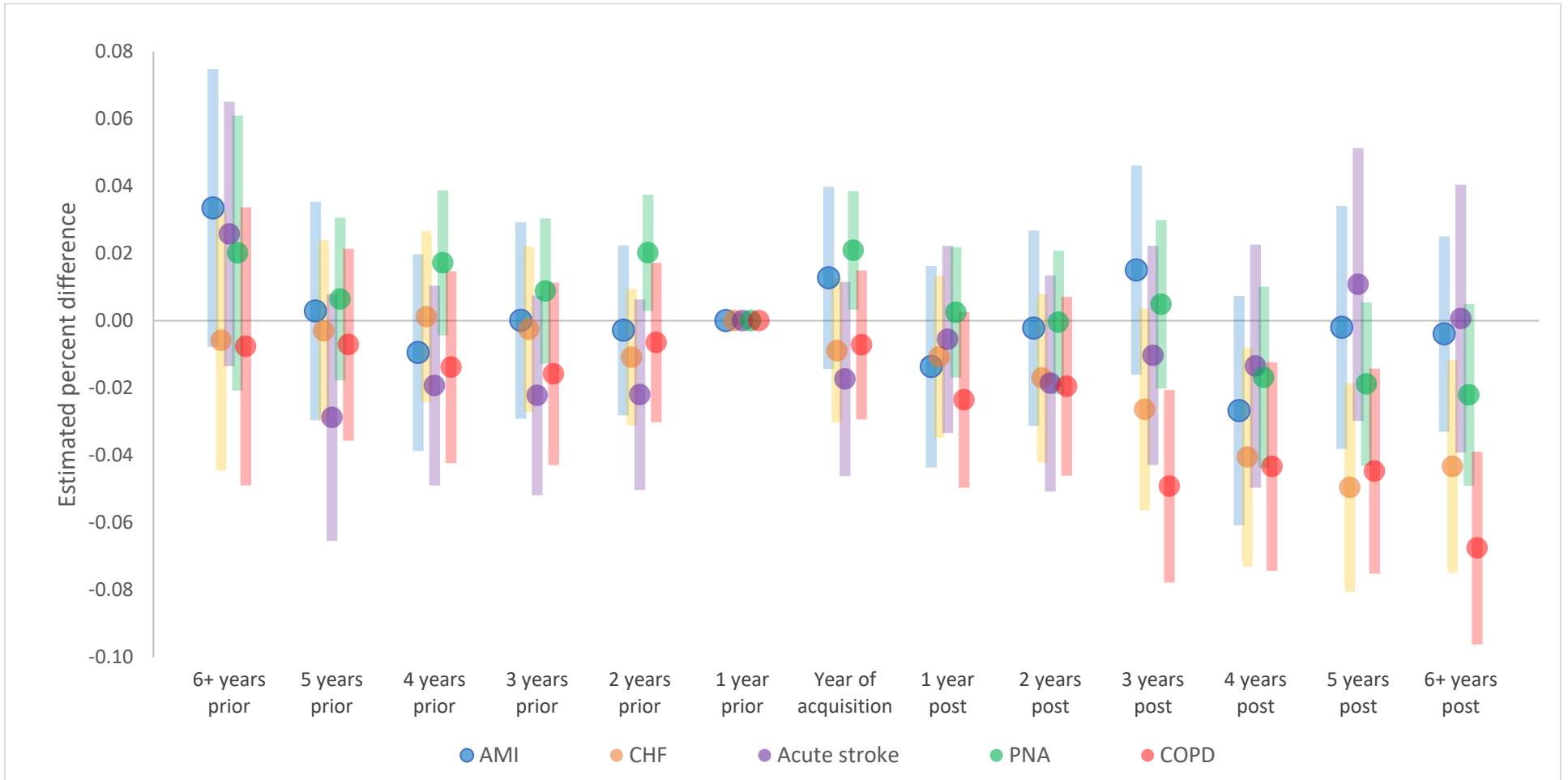
*Values are means and standard deviations.

eFigure 1. Event Study Plot for Patient Comorbidity (Elixhauser)



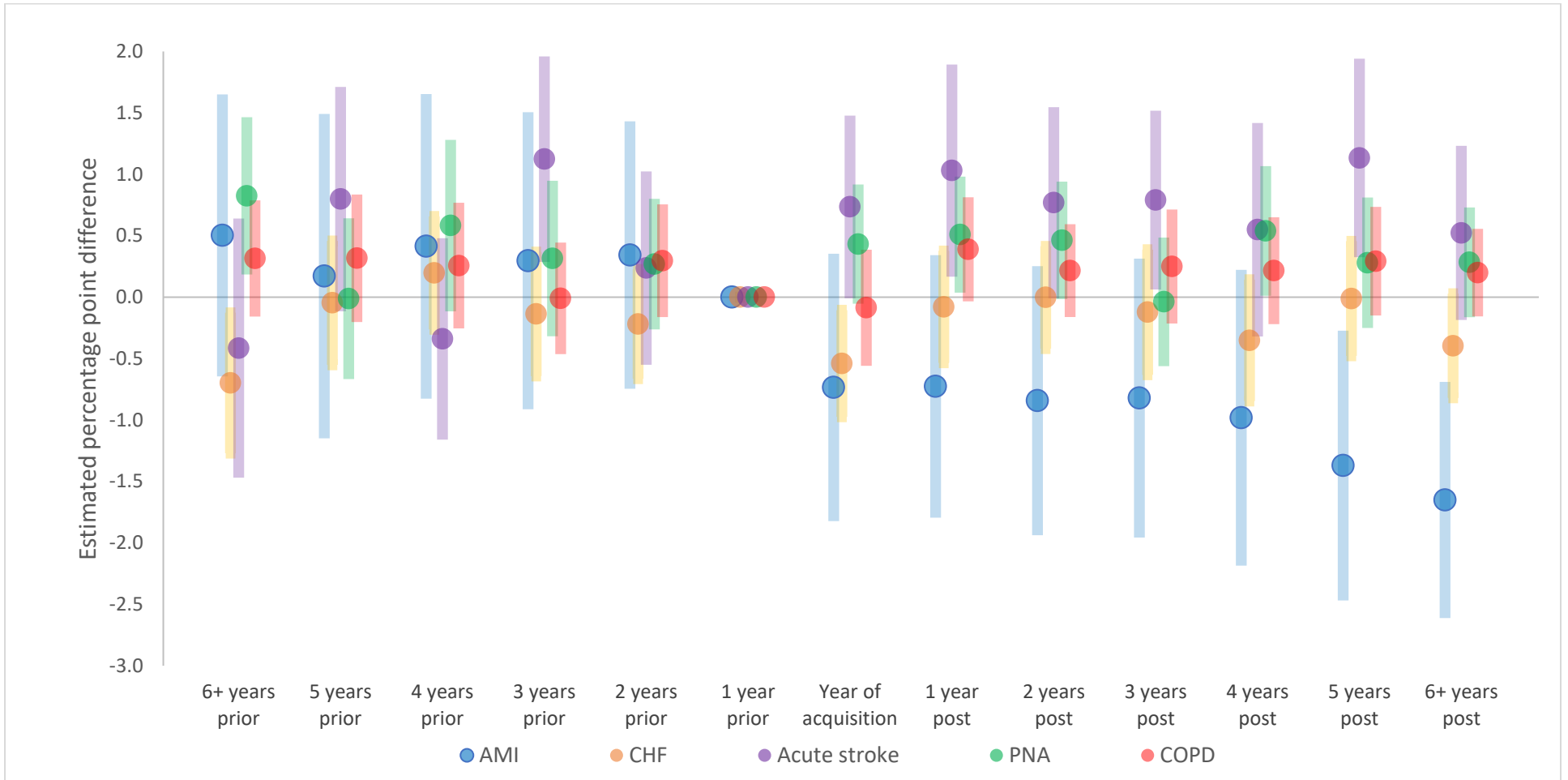
Condition	Pre-acquisition mean	Pre-trend p-value (5-year horizon)	Pre-trend p-value (4-year horizon)
AMI	1.588	0.72	0.73
CHF	2.897	0.48	0.34
Stroke	1.527	0.87	0.91
PNA	1.634	0.26	0.17
COPD	2.602	0.32	0.24

eFigure 2. Event Study Plot of Differences in Log-Transformed Length of Stay



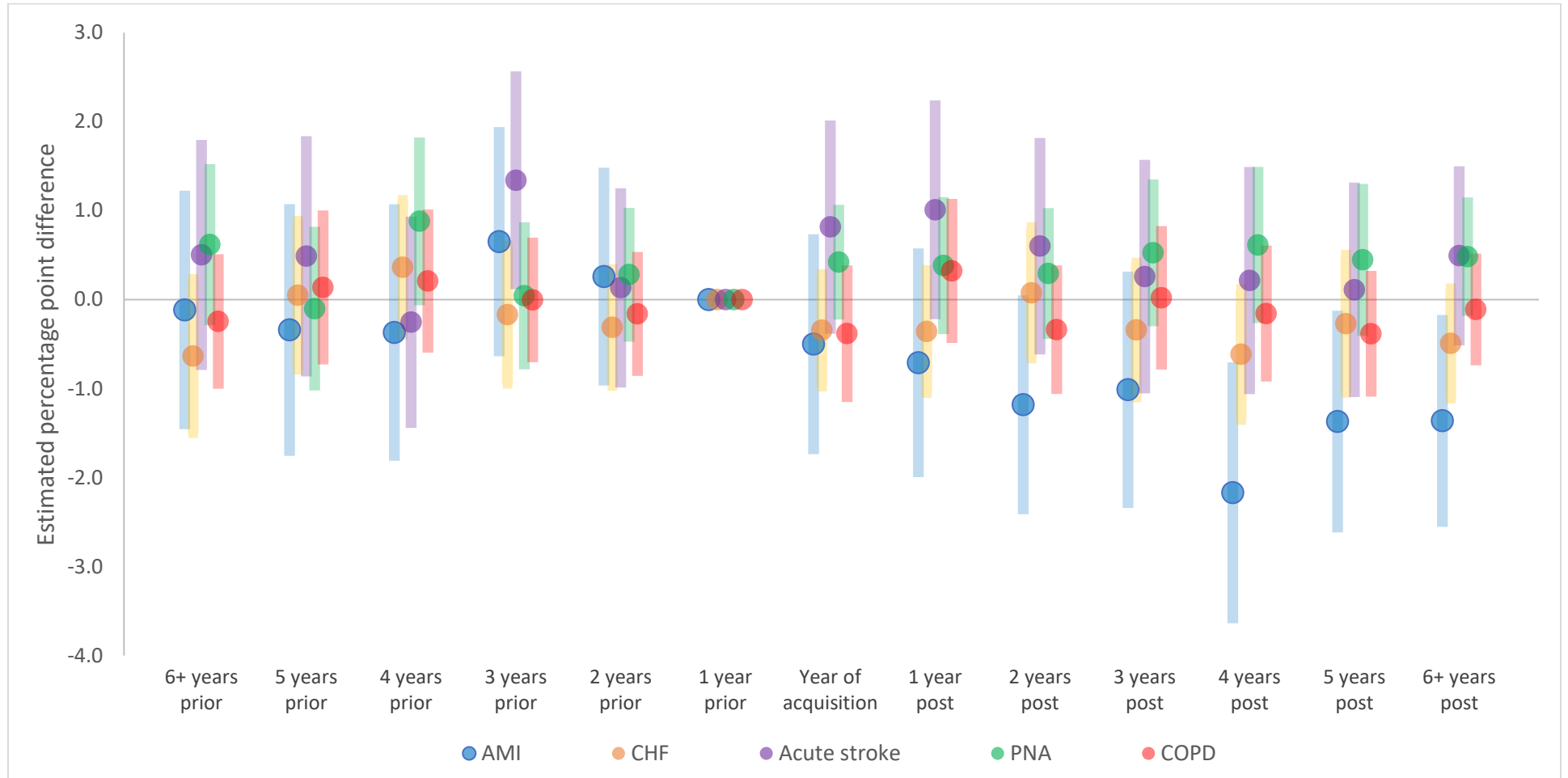
Condition	Pre-acquisition mean	Pre-trend p-value (5-year horizon)	Pre-trend p-value (4-year horizon)
AMI	1.449	0.49	0.90
CHF	1.458	0.75	0.62
Stroke	1.446	0.10	0.53
PNA	1.573	0.18	0.13
COPD	1.379	0.90	0.82

eFigure 3. Event Study Plot for Probability of In-Hospital Mortality



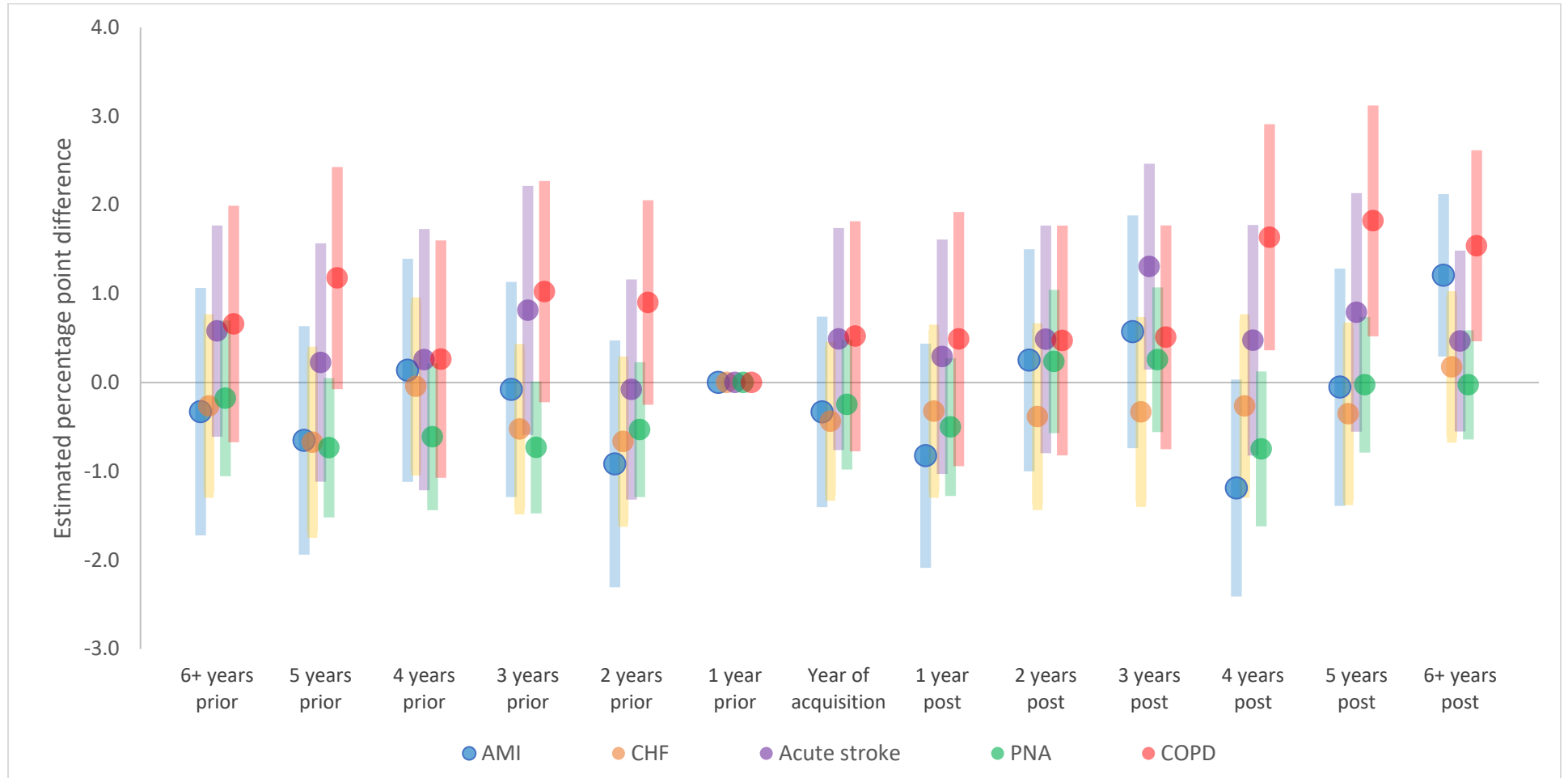
Condition	Pre-acquisition mean	Pre-trend p-value (5-year horizon)	Pre-trend p-value (4-year horizon)
AMI	10.4	0.96	0.96
CHF	4.2	0.04	0.57
Stroke	5.2	<0.01	<0.01
PNA	5.1	0.12	0.41
COPD	1.9	0.56	0.50

eFigure 4. Event Study Plot for Probability of 30-Day Mortality



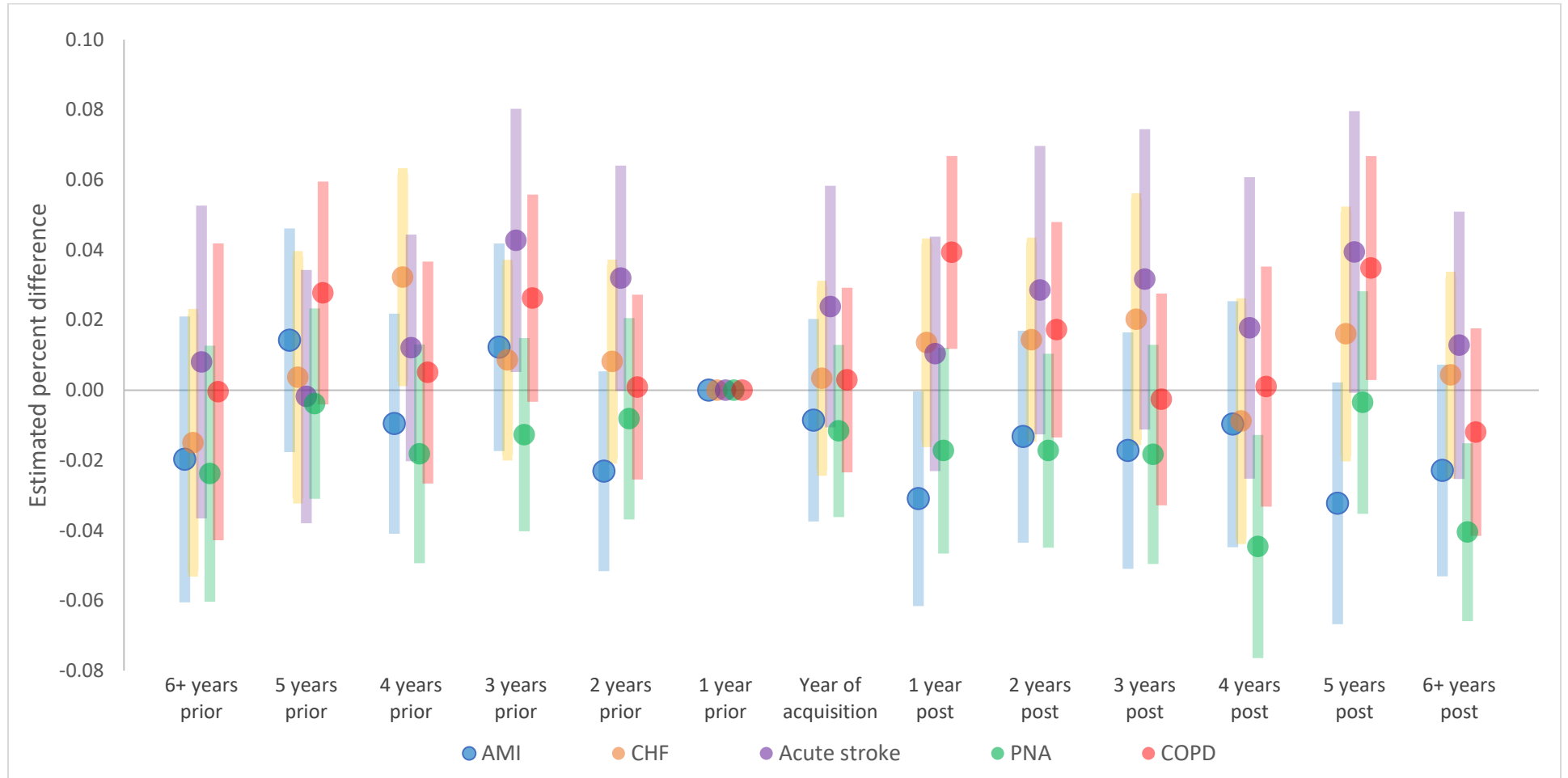
Condition	Pre-acquisition mean	Pre-trend p-value (5-year horizon)	Pre-trend p-value (4-year horizon)
AMI	17.6	0.63	0.49
CHF	11.2	0.18	0.53
Stroke	15.2	0.19	0.12
PNA	12.2	0.27	0.27
COPD	6.8	0.88	0.92

eFigure 5. Event Study Plot for Probability of 30-Day Readmission



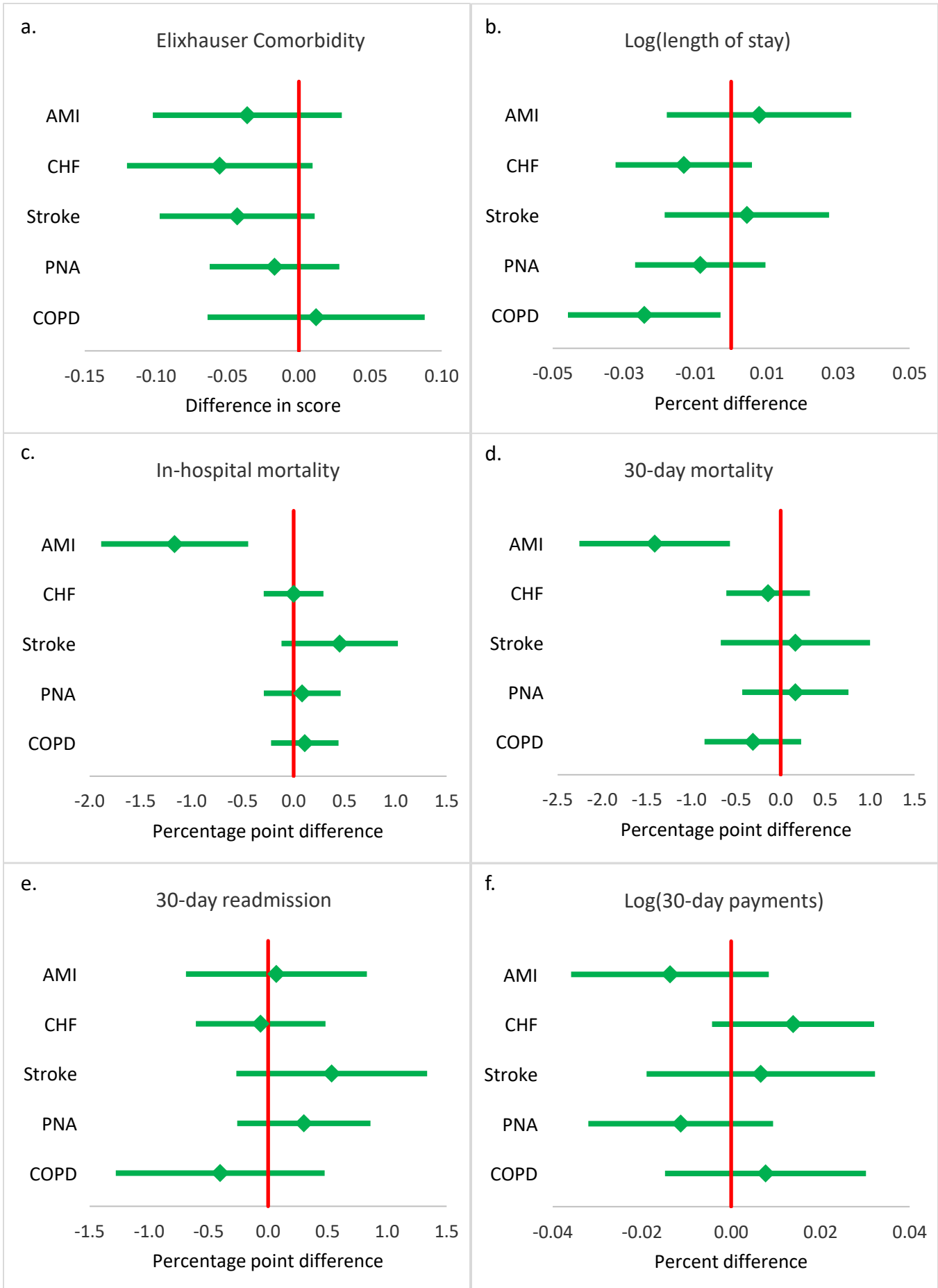
Condition	Pre-acquisition mean	Pre-trend p-value (5-year horizon)	Pre-trend p-value (4-year horizon)
AMI	18.2	0.72	0.61
CHF	19.2	0.48	0.35
Stroke	15.2	0.79	0.75
PNA	12.4	0.28	0.27
COPD	18.0	0.32	0.21

eFigure 6. Event Study Plot for Log-Transformed 30-Day Episode Payments



Condition	Pre-acquisition mean	Pre-trend p-value (5-year horizon)	Pre-trend p-value (4-year horizon)
AMI	9.598	0.14	0.13
CHF	9.285	0.06	0.14
Stroke	9.308	0.08	0.05
PNA	9.228	0.79	0.81
COPD	8.913	0.19	0.17

eFigure 7. Difference-in-Differences Estimates in Subsample of Hospital Referral Regions With at Least 1 Private Equity Acquisition



eFigure 8. Difference-in-Differences Estimates for HCA and Non-HCA Hospitals

