

Supplementary Online Content

Barnett ML, Olenski AR, Jena AB. Patient mortality during unannounced accreditation surveys at US hospitals. *JAMA Intern Med*. Published online March 13, 2017. doi:10.1001/jamainternmed.2016.9685

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

eMethods. Mortality Prediction Model Specification

To generate predicted mortality probabilities, we used admissions in the 100% MedPAR files for all hospitals in the study period from 2008-2012, in the years of a TJC survey. We specified the following model:

$$\text{logit}(E(Y_{i,j})) = \beta_0 + \beta_1 \text{Age}_{i,j} + \beta_2 \text{Sex}_j + \beta_3 \text{Race}_j + \beta_4 \text{CCW}_{i,j} + \beta_5 \text{DRG}_i + \beta_6 \text{Year}_i$$

where E denotes the expected value, $Y_{i,j}$ is the 30-day mortality of admission i for patient j , “age” represents the age of patient j at the time of admission i , “sex” is patient sex, “race” is patient race, “CCW” is a vector of the presence of 11 chronic conditions for patient j at the time of admission i (see Table 1 caption for more details), and “DRG” is a fixed effect for the diagnosis-related group of admission i . The predicted probabilities of mortality from this model were merged to each admission used in the main analysis in Table 2 and Table 3 and separated by the median into two groups: higher or lower 50th percentile of mortality.

eTable 1. Patient Characteristics in Major Teaching Hospitals

	Non-TJC Survey Weeks* (N=116,885)	TJC Survey Weeks (N=19,808)	p-value**
Female	52.2	52.0	0.705
White	68.9	68.9	0.964
Age (sd)	69.7 (14.5)	69.5 (14.5)	0.235
Length of Stay, Days (sd)	6.2 (8.0)	6.2 (7.9)	0.646
Total Medicare Payments (\$) (sd)	13,123.2 (19,954.3)	13,182.3 (19,360.7)	0.699
Weekly Admissions (sd)	253.0 (193.4)	257.2 (199.0)	0.859
Elixhauser Score	3.2 (1.8)	3.2 (1.8)	0.782
Presence of Chronic Illness, %***			
AMI/Ischemia	58.2	58.6	0.301
Alzheimers	16.2	16.2	0.915
Atrial Fibrillation	18.3	18.4	0.555
Chronic Kidney Disease	37.0	36.7	0.511
Chronic Obstructive Pulmonary Disease	32.2	32.3	0.853
Diabetes	44.3	44.6	0.449
Congestive Heart Failure	42.7	42.7	0.937
Hyperlipidemia	64.4	65.1	0.073
Hypertension	77.0	77.5	0.139
Stroke/TIA	18.9	18.9	0.961
Cancer	16.5	16.7	0.399

Abbreviations: The Joint Commission (TJC), standard deviation (SD), acute myocardial infarction (AMI), chronic obstructive pulmonary disease (COPD), transient ischemic attack (TIA)

* Non-TJC survey weeks are defined as the 6 weeks occurring 3 weeks before and after the week of TJC survey.

**P-values estimated using two sample t-tests or z-tests for proportions, as appropriate.

***Presence of chronic illness assessed using indicators from the Chronic Condition Warehouse File. "Cancer" includes presence of any of breast, endometrial, prostate or colon cancer

eTable 2. Number of Billing Providers by Week

Week relative to TJC survey	Number of billing providers (95% CI)*
-3	56.6 (54.8, 58.4)
-2	57.5 (55.6, 59.3)
-1	57.8 (55.9, 59.6)
0	56.6 (54.7, 58.4)
1	55.6 (53.8, 57.4)
2	55.1 (53.3, 56.9)
3	56.6 (54.7, 58.4)

Abbreviations: The Joint Commission (TJC), 95% confidence interval (95% CI)

* Number of billing providers defined as the number of unique national provider identifiers (NPIs) billing for any claim in the Medicare carrier file at a given hospital during each week relative to a TJC survey. 95% CI calculated assuming a normal distribution of provider counts given the large sample size of providers.

eTable 3. Adjusted Safety Measure Outcomes on Dates Surrounding TJC Surveys

Measure*	Subgroup	Non-TJC Week	TJC Week	Absolute Difference	Adjusted Difference**	95% CI	P-value
PSI-90	Overall (N=1,462,339)	1.29	1.31	0.02	0.02	(-0.03,0.07)	0.481
	<i>Teaching Hospital Status</i>						
	Other hospitals (N=1,344,046)	1.23	1.25	0.02	0.02	(-0.03,0.07)	0.474
	Major teaching hospital (N=116,885)	1.94	1.94	0.01	0.01	(-0.18,0.20)	0.913
	<i>CMS Total Performance Score Halves</i>						
	Total Performance Score (lower half) (N=943,887)	1.38	1.42	0.03	0.03	(-0.03,0.09)	0.291
	Total Performance Score (upper half) (N=481,270)	1.11	1.09	-0.02	-0.02	(-0.10,0.06)	0.571
	<i>Patient Expected Mortality Halves</i>						
	Expected mortality (lower half) (N=739,535)	0.80	0.82	0.02	0.01	(-0.03,0.06)	0.543
	Expected mortality (upper half) (N=722,804)	1.80	1.82	0.02	0.02	(-0.07,0.12)	0.636
C-Diff Rate	Overall (N=1,462,339)	1.47	1.48	0.00	0.01	(-0.04,0.06)	0.630
	<i>Teaching Hospital Status</i>						
	Other hospital(N=1,344,046)	1.46	1.46	0.00	0.01	(-0.05,0.06)	0.789
	Major teaching hospital (N=116,885)	1.65	1.69	0.03	0.08	(-0.10,0.25)	0.392
	<i>CMS Total Performance Score Halves</i>						
	Total Performance Score (lower half) (N=943,887)	1.47	1.46	-0.01	0.00	(-0.06,0.06)	0.943
	Total Performance Score (upper half) (N=481,270)	1.45	1.47	0.02	0.02	(-0.07,0.11)	0.600
	<i>Patient Expected Mortality Halves</i>						
	Expected mortality (lower half) (N=739,535)	0.60	0.58	-0.02	-0.02	(-0.07,0.04)	0.539
	Expected mortality (upper half) (N=722,804)	2.37	2.41	0.04	0.03	(-0.05,0.11)	0.407
Cardiac Arrest Mortality	Overall (N=8,376)	57.47	57.97	0.50	0.86	(-1.86,3.57)	0.536
	<i>Teaching Hospital Status</i>						
	Other hospital (N=7,660)	57.95	57.86	-0.09	0.39	(-2.44,3.23)	0.787
	Major teaching hospital (N=712)	52.25	59.17	6.92	6.18	(-2.87,15.22)	0.181
	<i>CMS Total Performance Score</i>						

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	<i>Halves</i>						
	Total Performance Score (lower half) (N=5,720)	58.01	58.74	0.73	1.02	(-2.36, 4.40)	0.55 3
	Total Performance Score (upper half) (N=2,487)	56.45	56.22	-0.23	0.40	(-4.30, 5.10)	0.86 8
	<i>Patient Expected Mortality Halves</i>						
	Expected mortality (lower half) (N=930)	40.86	41.29	0.43	1.81	(-6.23, 9.84)	0.66 0
	Expected mortality (upper half) (N=7,446)	59.55	60.02	0.47	0.71	(-2.12, 3.54)	0.62 4
PSI-04	Overall (N=37,594)	19.01	18.17	-0.84	-0.85	(-1.95, 0.25)	0.12 9
	Teaching Hospital Status						
	Other hospitals (N=34,262)	18.96	17.84	-1.12	-1.18	(-2.33, -0.03)	0.04 5
	Major teaching hospital (N=3,303)	19.61	21.88	2.27	2.75	(-0.82, 6.32)	0.13 1
	CMS Total Performance Score Halves						
	Total Performance Score (lower half) (N=24,785)	19.89	19.11	-0.78	-0.96	(-2.34, 0.41)	0.17 0
	Total Performance Score (upper half) (N=11,753)	17.41	16.34	-1.07	-0.77	(-2.68, 1.15)	0.43 4
	<i>Patient Expected Mortality Halves</i>						
	Expected mortality (lower half) (N=4,661)	3.81	4.47	0.66	1.03	(-1.81, 3.87)	0.47 7
	Expected mortality (upper half) (N=32,933)	21.16	20.11	-1.05	-0.97	(-2.16, 0.21)	0.10 6

Abbreviations: The Joint Commission (TJC), confidence interval (CI), Center for Medicaid and Medicare Services (CMS), PSI-90 (patient safety indicator 90, see Methods)

* See Methods for definitions of each secondary outcome.

** Adjusted results are estimated from logistic regression models comparing each secondary outcome between TJC survey weeks vs. non-survey weeks, with separate models estimated for each subgroup. All models adjusted for age, sex, race, the presence of any of 11 chronic illnesses (see Table 1) and major diagnostic category for admission. All analyses used robust variance estimators to account for clustering of admissions within hospitals. Absolute percentage changes in outcomes attributable to TJC surveys were estimated using a marginal standardization approach.

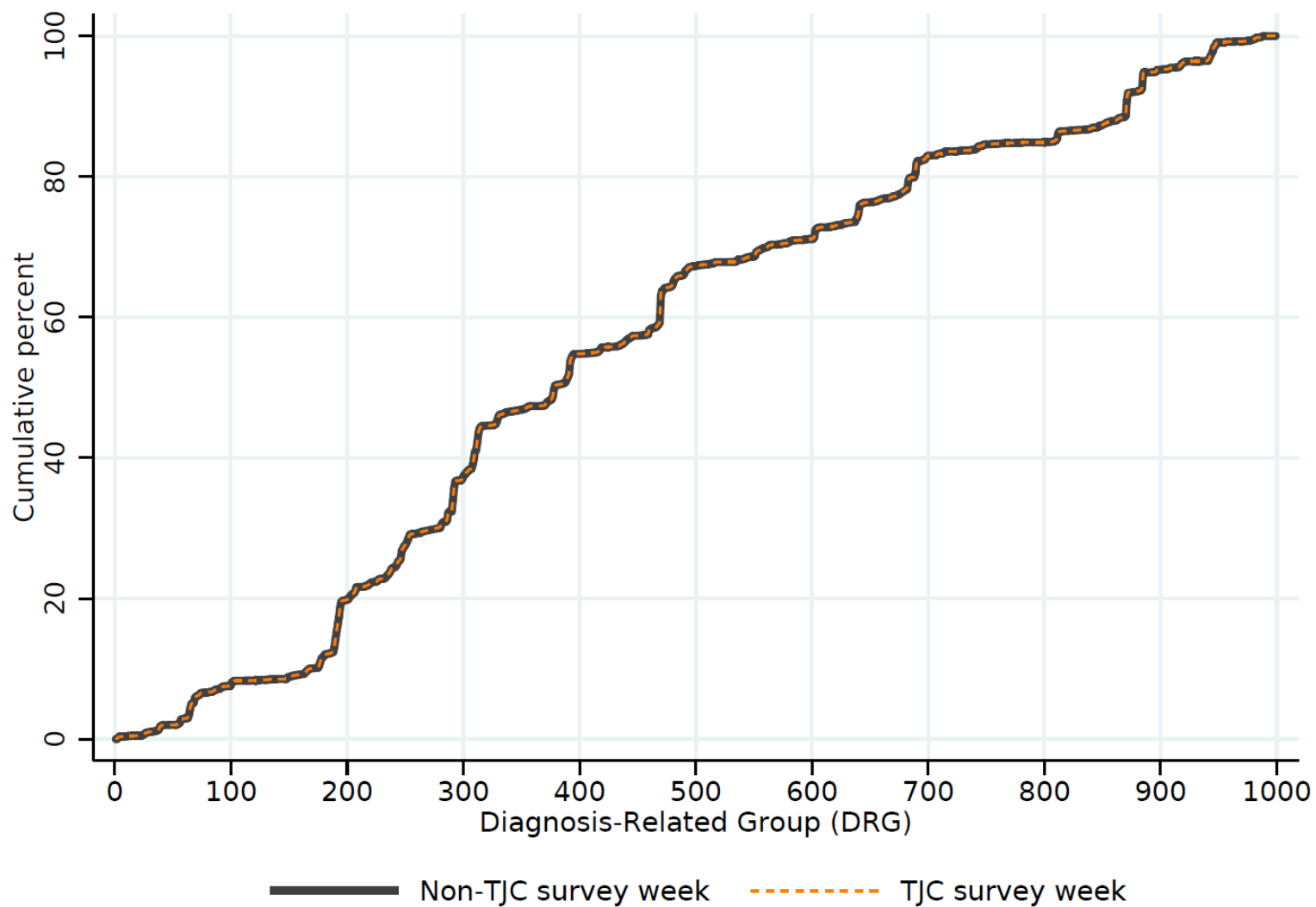
eTable 4. Sensitivity Analyses

Sensitivity Analyses	Non-TJC Week Adjusted Mortality*	TJC Week Adjusted Mortality*	Adjusted Mortality Difference (95% CI)*	P-value*
Major holidays excluded (N=1,697,548)**	7.19%	7.08%	-0.11 (-0.2, 0.0)	0.040
Emergency hospitalizations only (N=1,298,751)	8.70%	8.56%	-0.14 (-0.3, 0.0)	0.035
Subgroup analysis of patients hospitalized on Wednesdays/Thursdays/Fridays (N=978,608)	7.31%	7.15%	-0.16 (-0.3, 0.0)	0.029
Medical admissions only (N=1,177,792)	8.85%	8.75%	-0.10 (-0.2, 0.0)	0.157
Surgical admissions only (N=529,016)	3.53%	3.41%	-0.12 (-0.3, 0.0)	0.096

* Adjusted results are estimated from logistic regression models comparing 30-day mortality outcomes between TJC survey weeks vs. non-survey weeks, with separate models estimated for each subgroup. All models adjusted for age, sex, race, Elixhauser comorbidity score, the presence of any of 11 chronic illnesses (see Table 1) and major diagnostic category for admission. All analyses used robust variance estimators to account for clustering of admissions within hospitals. Absolute percentage changes in mortality attributable to TJC surveys were estimated using a marginal standardization approach.

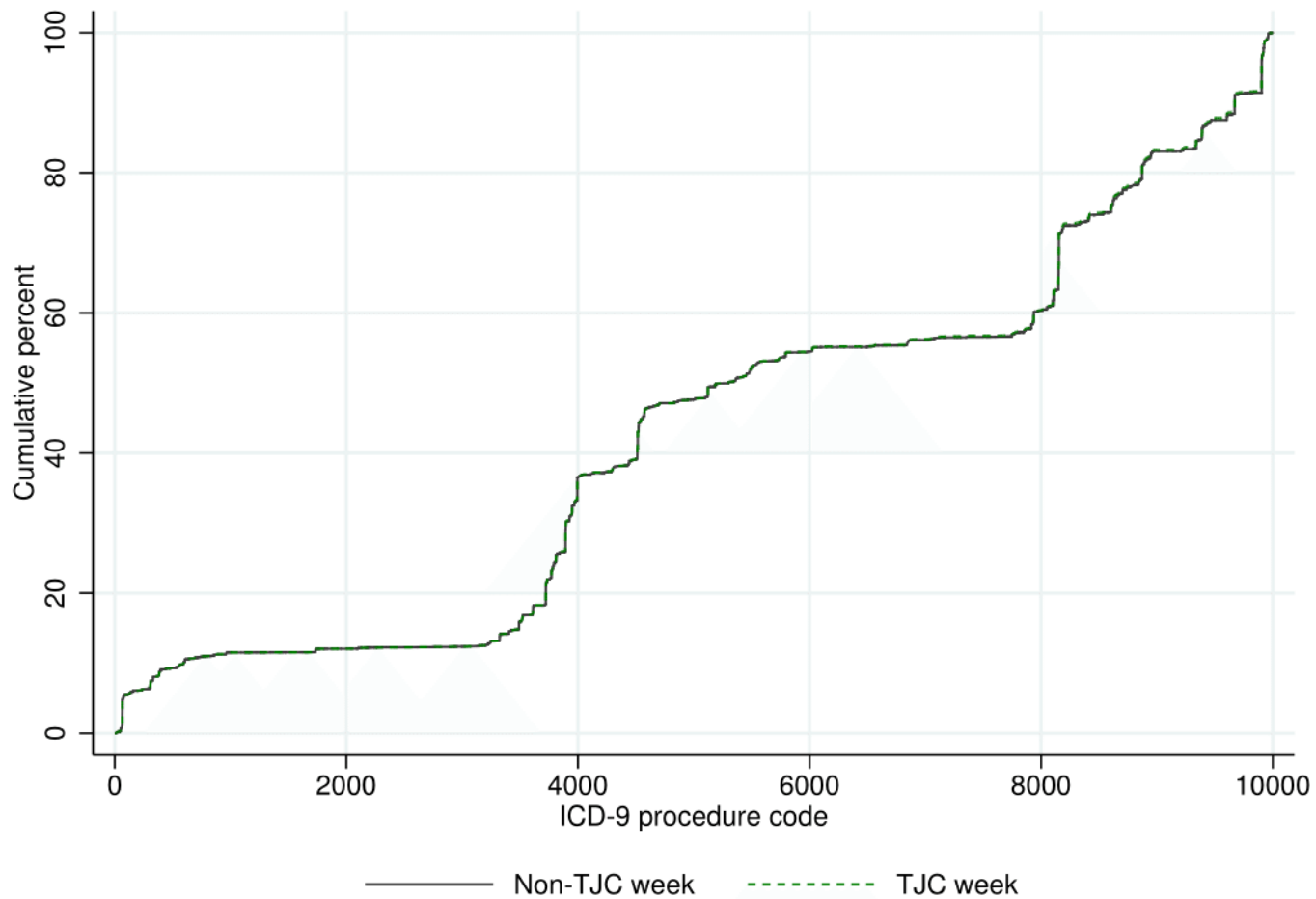
**Major holidays defined as Christmas Day, New Year's Day, Thanksgiving Day, and the Fourth of July.

eFigure 1. DRG Cumulative Distribution by TJC Survey Week



eFigure 1 shows cumulative distributions of the admitting Diagnosis-Related Groups (DRG) for all admissions in the study sample, separated by TJC survey (orange dashed) and non-TJC (black) survey weeks. Even though DRG numbers are categorical values representing separate diagnoses, we graphed the cumulative distribution on a continuous scale to visualize the case-mix of admissions across hundreds of DRGs. Therefore, the overlap between the TJC survey and non-TJC survey week distributions can reveal any subtle differences in case-mix across these many diagnoses.

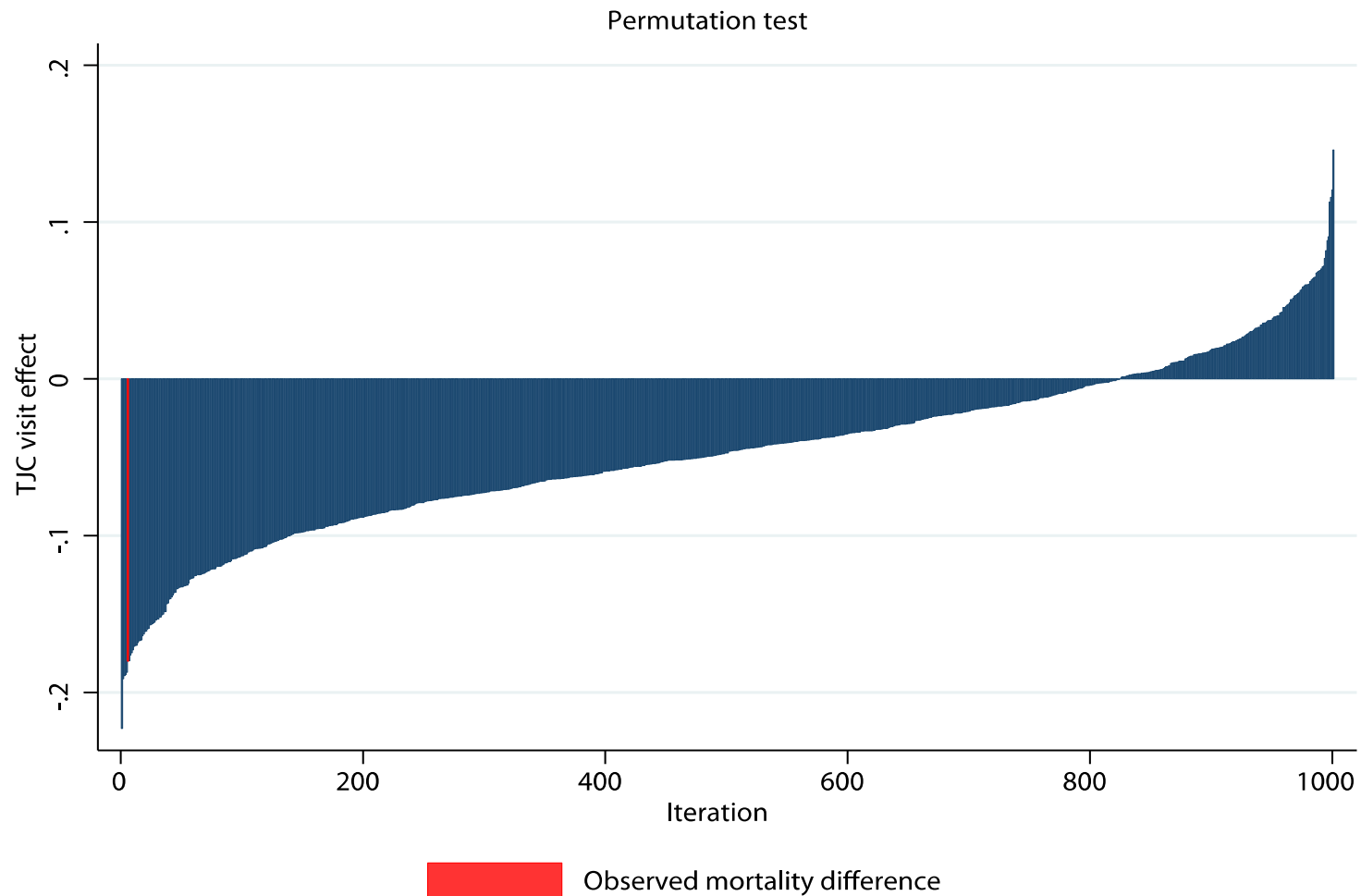
eFigure 2. ICD-9 Procedure Code Cumulative Distribution by TJC Survey Week



eFigure 2 shows cumulative distributions of the primary International Classification of Diseases (ICD-9) procedure codes for all admissions in the study sample that included a procedure, separated by TJC survey (green dashed) and non-TJC (black) survey weeks. As with eFigure 1, even though ICD-9 numbers are categorical values, we graphed the cumulative distribution on a continuous scale to visualize the procedural composition across thousands of ICD-9 codes. Therefore, the overlap between the TJC survey and non-TJC survey week distributions can reveal any subtle differences in procedural-mix across these many diagnoses.

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eFigure 3. Permutation Test: Distribution of Mortality Effect Sizes



eFigure 3 shows the calculated difference in mortality as an absolute percent between The Joint Commission (TJC) survey weeks vs. the surrounding 3 weeks before and afterwards (“TJC visit effect”) for 1,000 random permutations without replacement of the observed survey dates and the 1,984 hospitals surveyed. Effect sizes are arranged from lowest to highest. The red line shows the empirically observed mortality difference, which is lower than 995 of the 1,000 random permutations.