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Academic Season Does Not Influence Cardiac Surgical Outcomes at United States Academic Medical Centers

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Abstract

Objectives—Previous studies have demonstrated the influence of academic season on outcomes in select surgical populations. However, the influence of academic season has not been evaluated nationwide in cardiac surgery. We hypothesized that cardiac surgical outcomes were not significantly influenced by time of year at both cardiothoracic teaching hospitals (TH) and non-cardiothoracic teaching hospitals (NTH) nationwide.

Methods—From 2003–2007, a weighted 1,614,394 cardiac operations were evaluated using the Nationwide Inpatient Sample (NIS) database. Patients undergoing cardiac operations at TH and NTH were identified using the Association of American Medical College's Graduate Medical Education Tracking System. Hierarchical multivariable logistic regression analyses were utilized to estimate the effect of academic quarter on risk-adjusted outcomes.

Results—Mean patient age was 65.9±10.9 years. Females accounted for 32.8% of patients. Isolated coronary artery bypass grafting was the most common operation performed (64.7%) followed by isolated valve replacement (19.3%). The overall incidence of operative mortality and composite postoperative complication rate was 2.9% and 27.9%, respectively. After accounting for potentially confounding risk factors, timing of operation by academic quarter did not independently increase risk-adjusted mortality (p=0.12) or morbidity (p=0.24) at academic medical centers.

Conclusions—Risk-adjusted mortality and morbidity for cardiac operations are not associated with time of year in the United States at teaching and non-teaching hospitals. Patients should be reassured of the safety of performance of cardiac operations at academic medical centers throughout a given academic year.

Keywords

Academic Season; Cardiac Surgery; July Effect; July Phenomenon; Outcomes

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INTRODUCTION

The influence of season or time of year on patient outcomes has been a focus of recent public scrutiny. Seasonal variation has been demonstrated for various medical conditions, including coronary artery syndromes and ischemic heart disease.¹ Within United States (U.S.) academic medical centers, the academic year commences at the beginning of July. During this time, teaching institutions experience a significant transition in patient care with arrival of new interns, residents, and fellow physicians as well as other medical personnel. The presence of the so called “July phenomenon or effect” within academic medical centers refers to the influence of new trainees and inexperienced medical staff on patient and hospital related outcomes. The potential consequences of this effect within training institutions have been the focus of significant investigation.^{2–5} While inexperienced health practitioners are often targeted as a primary source of increased medical errors and compromised patient outcomes,^{6–8} recent evidence suggests an increase in fatal medical errors during the early academic year.⁹

The influence of new surgical trainees may impact certain surgical populations differently. For example, compromised patient outcomes as a function of time of year have been reported for general surgical populations.¹⁰ However, within surgical subspecialties, this effect may be attenuated by the presence of more experienced senior residents as well as by a higher level of supervision of new trainees. Within cardiothoracic surgery, several series have evaluated the effect of trainees on outcomes.^{2, 11, 12} These studies have documented short-term outcomes at either single institutions,^{11, 12} within the United Kingdom,¹² or within select Veterans Affairs (VA) patient populations² and have demonstrated an absence of a July effect at training hospitals. However, the influence of operative time of year has yet to be comprehensively investigated within a broad, generalizable, U.S. cardiac surgical patient population at academic institutions.

The objective of this study was to examine the effect of time of year by academic season on postoperative outcomes among cardiac surgery patients. We utilized a nationwide database to comprehensively evaluate the influence of academic quarter as a proxy for the influence of new cardiac surgical trainees within a large cardiac surgical patient population. We hypothesized that risk adjusted outcomes would not be impacted by operative time of year at both teaching and non-teaching hospitals.

METHODS

Data Source

The University of Virginia Institutional Review Board (IRB) did not perform a formal review of this study as it was determined that the contents do not meet the regulatory definition of human subjects research due to the absence of patient identifiers and the fact that the data is collected for purposes other than research. Data analyzed include patient discharge records and variables obtained from the Nationwide Inpatient Sample (NIS) databases for the years 2003–2007 (<http://www.hcup-us.ahrq.gov/db/nation/nis/nisdde.jsp>). The NIS databases are the largest inpatient care databases in the United States that are publically available. The NIS datasets represent an approximate 20% stratified random sample of all U.S. hospital discharges and includes those hospitals designated as “community hospitals” within the American Hospital Association (AHA) Annual Survey. Each discharge record includes a specific discharge weight to represent the relative proportion of the total U.S. in-patient hospital population for each record.

Patients

We used International Classification of Diseases-Ninth Revision, Clinical Modifications (ICD-9-CM) procedure and diagnostic codes to identify all isolated cardiac operations: coronary artery bypass grafting (CABG, ICD-9-CM codes 361, 3610, 3611, 3612, 3613, 3614, 3615, 3616), valve replacement (ICD-9-CM codes 352, 3520, 3521, 3522, 3523, 3524, 3525, 3526, 3527, 3528), or valve repair (ICD-9-CM codes 351, 3511, 3512, 3513, 3514). Patients were stratified by academic operative quarter: Academic Quarter 1 (AQ1: July–September), Academic Quarter 2 (AQ2: October–December), Academic Quarter 3 (AQ3: January–March), and Academic Quarter 4 (AQ4: April–June). Patient co-morbid disease was assessed using Elixhauser co-morbidity categories, which were provided with the NIS datasets.¹³ The use of these categories has been demonstrated to provide effective adjustments for mortality risk.¹⁴

Hospitals

Hospital details reflect those reported in the NIS database as well as within the Association of American Medical College's Graduate Medical Education Tracking System. Cardiothoracic surgery teaching hospitals (TH) were those where cardiothoracic surgery trainees from established Accreditation Council for Graduate Medical Education (ACGME) training programs obtained $\geq 50\%$ of their training. TH status was identified through linking of AHA identification numbers within the NIS dataset with the Association of American Medical College's Graduate Medical Education Tracking System. Hospital operative volume was categorized into quartiles: Low [$<25^{\text{th}}$ percentile], Medium [26–49th percentile], High [50–74th percentile], and Very High [$>75^{\text{th}}$ percentile].

Outcomes Measured

All measured outcomes were established *a priori* before data collection and analysis to reduce the false discovery rate and the inherent bias of multiple hypothesis testing. Primary outcomes were risk-adjusted in-hospital mortality and composite complications. Secondary outcomes were hospital length of stay and total costs. In-hospital complications were categorized using a systems-based ICD-9 coding scheme including mechanical wound, infectious, genitourinary, pulmonary, gastrointestinal, cardiovascular, systemic and procedure related complications as previously described.¹⁵ Death, median length of stay, and total charges were determined from patient discharge records.

Statistical Analysis

All statistical methodology were utilized to test the null hypothesis that outcomes following performance of cardiac surgical operations are not significantly different with respect to operative time of year. Statistical significance was set by an alpha of <0.05 . Observed differences in unadjusted mortality and morbidity were compared by univariate analyses: Pearson's χ^2 test (categorical variables) and analysis of variance (ANOVA) for continuous variables. Categorical variables are expressed as a percentage of the group of origin, while mean $\pm$ standard deviation or median [interquartile range] is used for all normally distributed and non-normally distributed continuous data, respectively. Odds ratios (OR) with a 95% confidence interval (CI) report the results of logistic regression models. Calculated test statistics were used to determine reported *P*-values. All *P*-values are unpaired and two-tailed. Due to the complex sampling methods utilized within the NIS, all data analyses were performed using Predictive Analytics SoftWare (PASW) Statistics version 18.0.0 complex samples module (IBM Corporation, Somers, NY)..

Multivariable logistic regression analyses were used to estimate risk adjusted mortality and morbidity among patients undergoing cardiac surgery operations as a function of academic

quarter. All model covariates (patient age, gender, elective operative status, hospital geographic region, cardiothoracic surgery teaching hospital status, type of operation, operative year, operative volume, and categories for co-morbid disease) were selected *a priori* and were retained in the final models. Each statistical model included appropriate adjustments the weighted study population. The Wald χ^2 test was used to assess statistical significance of the association between academic quarter and in-hospital mortality. The performance of each model was assessed by the Area Under the Receiver Operating Characteristics Curve (AUC) and the Nagelkerke Pseudo R^2 goodness-of-fit test.

Sensitivity analyses were performed to validate the estimated effect of each model. Statistical validity was assessed by re-estimating each model after removing the most statistically significant covariate as measured by the Wald χ^2 statistic. With this approach, the potential for spurious results is reduced if the originally observed effect is not substantially attenuated and remains statistically significant after re-estimation.¹⁶ After re-estimation, the effect of academic quarter on the estimated odds of patient death was not significantly attenuated (<10%).

RESULTS

Patient and Hospital Characteristics

From 2003–2007, we analyzed 260,780 cardiac surgery discharge records, representing a weighted estimate of 1,614,394 patients nationwide. Descriptive statistics for all patient, hospital and operative characteristics are listed in Table 1. Mean patient age was 65.9 ± 10.9 years, and females accounted for 32.8% of all patients. Isolated CABG was the most commonly performed operation followed by isolated valve replacements and combined CABG/valve procedures. Among valve operations, aortic valve replacement (20.9%) was the most common procedure, followed by mitral valve replacement (7.8%) and repairs (6.0%). Patients undergoing cardiac operations within the study cohort presented with well-documented co-morbid disease: hypertension (68.6%), diabetes (29.8%), peripheral vascular disease (12.3%), and chronic pulmonary disease (19.8%). Performance of cardiac surgery operations among different mean income quartiles demonstrated incremental differences (I: 23.3%, II: 24.5%, III: 24.6%, IV: 27.6%).

With respect to hospital characteristics, the large majority of cardiac operations occurred in an urban setting and within large hospital bed size hospitals. The Northeast and Southern geographic regions performed the highest proportion of operations. Cardiac operations were more commonly performed at very high-volume (>75th percentile operative volume) centers. The distribution of operations was similar in each academic quarter. The median hospital length of stay was 8.0 [6.0–11.0] days and the median total charges were \$77,655.00 [\$55,651.00–\$117,161.00].

Univariate Associations Between Academic Quarter and Postoperative Morbidity and Mortality

Univariate analyses for the effect of academic quarter on mortality (Table 2) and the composite incidence of any postoperative complication (Table 3) revealed few differences between operative time of year and outcomes within all hospitals. The overall incidence of operative mortality was 2.9%, while the incidence of any postoperative complication was 27.9%. Upon stratification by academic quarter, mortality was not found to be significantly affected by performance of cardiac operations during academic quarters I, II, or IV. Similarly, academic quarter was not found to be a significant determinant of unadjusted complication rates during the academic quarters I and III.

Risk-Adjusted Associations of Morbidity and Mortality

Adjusted odds ratios for the effects of academic quarter and TH status were further estimated using hierarchical multivariable logistic regression methods. After adjustment for the concurrent effects of patient, hospital and operative factors, academic quarter was not an independent predictor of in-hospital mortality ($P=0.21$) or the composite outcome of any postoperative complication ($P=0.15$) among all patients undergoing cardiac surgical operations. Similarly, performance of cardiac operations at TH did not significantly increase the odds of mortality ($P=0.13$) or postoperative complications ($P=0.97$) compared to NTH. Upon testing of an interaction term between the effects of academic quarter and teaching hospital status in each multivariable model, the effect of academic quarter on the odds of mortality ($P=0.12$) or postoperative complications ($P=0.24$) did not depend upon teaching hospital status (Table 4). Furthermore, the odds of in-hospital death were significantly increased for valve replacement (OR=2.75 [2.44–3.08], $P<0.001$), valve repair (OR=2.72 [2.10–3.52], $P<0.001$) and combined operations (OR=1.79 [1.68–1.90], $P<0.001$) operations compared to isolated CABG operations.

DISCUSSION

Herein, we demonstrate that risk-adjusted in-hospital mortality and morbidity following cardiac surgery operations in the United States do not depend upon operative time of year. In these analyses, the effects of academic quarter and cardiothoracic surgery teaching hospital status did not independently influence mortality or the composite incidence of postoperative complications for patients undergoing a variety of commonly performed cardiac operations. Consequently, operative time of year does not appear to be a predictor for mortality or morbidity at cardiothoracic surgery teaching hospitals. In addition, this study highlights important trends that exist within United States hospitals including higher risk-adjusted mortality for the performance of complex cardiac operations as well as regional differences in the performance of cardiac operations.

The potential for a “July phenomenon” has been postulated as a potential explanation for variations in patient outcomes following both medical and surgical hospitalizations at academic centers. This proxy as a measure of resident experience has been investigated within various patient populations with mixed results.^{2–5, 10} Englesbe and colleagues (2007) from the University of Michigan reported a large, multi-institutional cohort study of 20,254 patients undergoing a variety of surgical operations using data from the American College of Surgeons-National Surgical Quality Improvement Program (NSQIP). In their study, 30-day mortality rates for patients undergoing operations at beginning of an academic year (July 1–August 30) were 41% higher than the end of the year (April 15–June 15).¹⁰ However, this study fails to provide details related to surgical case mix, and it remains unclear how many cardiac or vascular operations were included in their analyses. A similar study by Rich and colleagues (1993) demonstrated the presence of a “July effect” on patient outcomes following internal medicine admissions.⁴ However, other published surgical series involving Medicare and trauma patients have failed to demonstrate a significant influence of operative time of year on surgical outcomes.^{3, 5}

Our results demonstrate that operative time of year does not independently influence patient mortality following the performance of common, cardiac operations at academic institutions. These findings are in general agreement with previous studies examining the influence of resident experience on cardiac surgical outcomes. Of the few published series, the largest to date was performed by Bakaeen and colleagues in 2009. In this retrospective review, the authors demonstrated similar risk-adjusted morbidity (OR=1.01 [0.96–1.07], $P=0.67$) and operative mortality (OR=0.99 [0.89–1.11] $P=0.90$) for cardiac surgical patients undergoing operations during early (July 1–August 31) and late (September 1–June 30) periods of an

academic year using the Veterans Affairs (VA) Continuous Improvement in Cardiac Surgery Program (CICSP) database. Although limited by the inclusion of VA patients only, the representation of select affiliated academic medical centers, and a ten-year study period (10/1997–10-2007) that witnessed significant changes in resident work hour restrictions, their results concur with our findings. Two additional single institution studies also support our results and found no effect of cardiothoracic surgical resident turnover or experience as a function of academic season on the outcomes of cardiac procedures.^{11, 12}

The findings of this study extend the examination of resident work experience and the investigation of academic season to reflect contemporary trends at academic medical centers operating within current resident training hours restrictions. In our analyses, we controlled for a potential 45 patient, hospital and operation related confounding factors, including cardiothoracic surgery teaching hospital status and the surprisingly high prevalence (50.35%) of non-elective operative status, in each of our predictive models. Importantly, the concomitant influence of academic quarter and cardiothoracic surgery teaching hospital status was assessed through the inclusion of an interaction term between these two variables in each statistical model. Even after these adjustments, performance of cardiac surgical operations during a given academic quarter at cardiothoracic surgery teaching hospitals was not associated with patient mortality.

The additional contribution of system-related influences must be considered in our analysis of patient outcomes at academic medical centers. In our analysis, we used academic quarter as a proxy for the unmeasured influence of new surgical trainees on cardiothoracic surgery patient outcomes. Although the potential lack of experience of new trainees during the early academic season would most likely exert the largest direct influence on patient outcomes, other system related processes, including attending coverage, fluctuations in nursing staff schedules, transitions in allied health care personnel, team debriefing and handing off of patient care between surgical teams may exert important influences during early academic seasons. The current study can not account for these immeasurable factors as these variables are not prospectively collected and available in the NIS database. In addition, we were unable to statistically control for the influence of resident and attending surgeon experience with respect to the number of clinical years of training and/or surgical practice. Thus, it is possible that more senior cardiothoracic residents and/or attending surgeons performed a higher percentage of more complex operations and/or the postoperative care during the study period.

This study has important clinical relevance as it provides a nationally representative and broadly generalizable sampling of an increasingly reported phenomenon within academic medical centers. To our knowledge, this study represents the most comprehensive investigative description of the influence of academic seasonality within a nationwide, cardiac surgical patient population. As surgical subspecialty care often requires more specified postoperative management, we believe that the lack of differences in patient outcomes at the beginning of an academic year compared to the end may represent the influences of a higher level of supervision from more senior surgical trainees and attending surgeons, the presence of more mid-level providers (physicians assistants and nurse practitioners), and the utilization of more protocolized postoperative treatment algorithms and/or pathways. Consequently, our results are hypothesis generating and provide a legitimate clinical context for future prospective studies. Additionally, we believe our data dispels the belief that cardiac surgery patient outcomes may be adversely affected at teaching institutions during the early academic season, and that patients should be reassured of the safety of performance of cardiac surgery operations at academic medical centers throughout the academic year.

This study has certain limitations. The retrospective study design and use of an administrative database introduces the possibility of selection bias, especially at the surgeon level, and the potential for errors due to any unrecognized miscoding of diagnostic, procedure, and complication codes. However, the strict randomization and annual validation of the NIS dataset reduces the likelihood such bias. In addition, the NIS lacks data collection for several important factors, including affiliate teaching status for non-teaching hospitals, level of resident training, intraoperative role of trainees, or precise transition points in patient care at the beginning or end of resident service rotations. Constraints imposed by collected data points and the confinements of variable definitions, such as renal failure and elective vs. non-elective status, should be considered. Alternatively, other cardiac specific databases, such as the Society of Thoracic Surgeons (STS) Adult Cardiac Surgery database, may provide for more specific adjustment of certain patient and operation related factors. The present results should also be evaluated within such databases. The lack of long-term follow-up data may result in the underestimation of true mortality and morbidity rates. Additionally, the use of in-hospital mortality as reported within the NIS does not provide estimates of 30-day mortality, and this study did not analyze mortality related to hospital re-admissions or include other high risk cardiac operations such as thoracic aorta or aortic root procedures. Finally, we are unable to include adjustments for other well-established surgical risk factors such as low preoperative albumin levels or poor nutrition status or the influence of an unmeasured confounder, which limits the ability to completely risk stratify patients. However, our statistical models proved resilient to the presence of a potentially unmeasured confounder on sensitivity analysis.

CONCLUSION

Risk-adjusted mortality and morbidity are not significantly different with respect to operative time of year at both teaching and non-teaching hospitals. Mortality and morbidity following the performance of cardiac operations during the early academic season is not significant different from those of later academic quarters at U.S. academic medical centers. Patients should be reassured of the safety of undergoing of cardiac operations at teaching institutions throughout a given academic year.

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Table 1

Descriptive statistics for all patient, hospital and operative characteristics.

Covariate	Frequency (n=260,780)	Weighted Frequency (n=1,614,394)	Statistic *
In-hospital Mortality	7,594	37,068	2.90%
Any Postoperative Complication **	72,716	355,828	27.90%
Patient Age (years)			65.97±10.92
Female	85,536	529,521	32.80%
Elective Operation	129,738	803,161	49.75%
Operation			
Isolated CABG	168,725	1,044,513	64.70%
Isolated Valve Replacement	50,200	310,771	19.25%
Isolated Valve Repair	14,343	88,792	5.50%
Combined CABG + Valve	27,643	171,126	10.60%
Aortic Valve Replacement	54,373	336,601	20.85%
Mitral Valve Replacement	20,341	125,923	7.80%
Mitral Valve Repair	15,647	96,864	6.00%
Pulmonic Valve Replacement	2,217	13,722	0.85%
Tricuspid Valve Replacement	1,174	7,265	0.45%
Elixhauser Comorbid Disease Category			
AIDS	130	807	0.05%
Alcohol abuse	5,868	36,324	2.25%
Deficiency Anemia	29,468	182,427	11.30%
RA and Collagen Vascular Disease	3,912	24,216	1.50%
Chronic Anemia	2,999	18,566	1.15%
Congestive Heart Failure	3,129	19,373	1.20%
Chronic Pulmonary Disease	51,504	318,843	19.75%
Coagulopathy	22,166	137,223	8.50%
Depression	10,040	62,154	3.85%
Diabetes (uncomplicated)	77,712	481,089	29.80%
Diabetes (complicated)	13,821	85,563	5.30%
Drug Abuse	2,217	13,722	0.85%
Hypertension	178,765	1,106,667	68.55%
Hypothyroidism	17,211	106,550	6.60%
Liver Disease	2,477	15,337	0.95%
Lymphoma	1,043	6,458	0.40%
Fluid and Electrolyte Disorder	38,726	239,738	14.85%
Metastatic Cancer	261	1,614	0.10%
Neurologic Disorder	6,128	37,938	2.35%
Obesity	25,426	157,403	9.75%
Paralysis	2,738	16,951	1.05%
Peripheral Vascular Disease	31,946	197,763	12.25%
Psychoses	2,869	17,758	1.10%

Covariate	Frequency (n=260,780)	Weighted Frequency (n=1,614,394)	Statistic*
Pulmonary Circulatory Disease	261	1,614	0.10%
Renal Failure	21,123	130,766	8.10%
Tumor (no metastases)	2,738	16,951	1.05%
Peptic Ulcer Disease	130	807	0.05%
Valve Disease	1,956	12,108	0.75%
Weight Loss	3,521	21,794	1.35%
Mean Income Quartile			
I	60,762	376,154	23.30%
II	63,761	394,719	24.45%
III	64,021	396,334	24.55%
IV	71,975	445,573	27.60%
Rural Location	5,998	37,131	2.30%
Cardiothoracic Teaching Hospital	21,962	135,609	8.40%
Hospital Bed Size			
Small	12,126	75,069	4.65%
Medium	32,467	200,992	12.45%
Large	216,317	1,339,140	82.95%
Hospital Region			
Northeast	85,927	531,943	32.95%
Midwest	52,026	322,072	19.95%
South	82,537	510,956	31.65%
West	40,291	249,424	15.45%
Hospital Operative Volume Quartile			
Low	6,780	41,974	2.60%
Medium	26,469	163,861	10.15%
High	48,375	299,470	18.55%
Very High	179,156	1,109,089	68.70%
Academic Quarter			
I (July–September)	62,718	388,262	24.05%
II (October–December)	62,848	389,069	24.10%
III (January–March)	67,803	419,742	26.00%
IV (April–June)	67,281	416,514	25.80%
Operative Year			
2003	57,763	357,588	22.15%
2004	53,981	334,180	20.70%
2005	50,200	310,771	19.25%
2006	51,634	319,650	19.80%
2007	47,201	292,205	18.10%

* Results reported as % of total population or mean $\pm$ standard deviation. CABG=coronary artery bypass graft; AIDS=adult immunodeficiency syndrome; RA= rheumatoid arthritis.

** Refers to the composite incidence of any of the following postoperative complication categories: mechanical wound, infectious, genitourinary, pulmonary, gastrointestinal, cardiovascular, systemic and procedure related complications.

Table 2

Univariate analyses for the effect of academic quarter on mortality.

Variable	Survivors	Mortality	Unadjusted Odds Ratio (95% C.I.)	<i>p</i>
Academic Quarter				
I (July–September)	97.1%	2.9%	0.99 (0.94–1.04)	0.69
II (October–December)	97.1%	2.9%	0.98 (0.93–1.03)	0.42
III (January–March)	97.0%	3.0%	1.06 (1.00–1.11)	0.04
IV (April–June)	97.1%	2.9%	0.98 (0.93–1.03)	0.37

CI=confidence interval

Table 3

Univariate analyses for effect academic quarter on the incidence of postoperative complications.

Variable	No Complication	Complication	Unadjusted Odds Ratio (95% C.I.)	<i>p</i>
Academic Quarter				
I (July–September)	72.0%	28.0%	1.01 (0.99–1.03)	0.31
II (October–December)	71.5%	28.5%	1.04 (1.02–1.06)	<0.001
III (January–March)	72.3%	27.7%	0.99 (0.97–1.01)	0.99
IV (April–June)	72.7%	27.3%	0.96 (0.95–0.98)	<0.001

CI=confidence interval

Table 4

Adjusted odds ratios for the interaction of effects between academic quarter and cardiothoracic surgery teaching hospital status on in-hospital outcomes.

Covariate	Odds Ratio	95% Confidence Interval	P-value
<i>In-Hospital Mortality Model[†]</i>			0.12
Academic Quarter I	0.77	0.61–0.97	
Academic Quarter II	0.90	0.72–1.13	
Academic Quarter III	0.98	0.79–1.22	
Academic Quarter IV (Reference)	1.00	-	
<i>In-Hospital Complication Model[‡]</i>			0.24
Academic Quarter I	0.93	0.85–1.01	
Academic Quarter II	1.01	0.92–1.10	
Academic Quarter III	0.97	0.89–1.06	
Academic Quarter IV (Reference)	1.00	-	

Model performance:

[†] Area Under Receiver Operator Curve (AUC)=0.81, Nagelkerke Psueduo R^2 =0.17 with 60 degrees of freedom;

[‡] AUC=0.74, Nagelkerke Psueduo R^2 =0.08 with 60 degrees of freedom. Models adjusted for all covariates: age, gender, mean income, elective operative status, operative year, hospital teaching status, hospital region, hospital location, hospital operative volume, cardiac operation type, academic quarter, Elixhauser comorbid disease categories. Reference Groups: Teaching Hospital Status (Non-Cardiothoracic Teaching Hospital); Academic Quarter (IV).