The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP®) was developed by surgeons a decade ago to help hospitals measurably improve patient outcomes and save lives. Today, ACS NSQIP remains the first and only nationally validated, risk-adjusted, outcomes-based program to measure and improve the quality of surgical care across surgical specialties in the private sector.

The program dates back to the mid-1980s, when the Department of Veterans Affairs (VA) developed NSQIP to help its 133 hospitals measure quality of care based on preoperative risk factors and postoperative outcomes. VA hospitals found great success with the program. Hospitals were able to decrease postoperative mortality rates by 47 percent and morbidity rates by 43 percent between 1991 and 2006. Additionally, VA hospitals saw median length of stay fall from nine to four days, and patient satisfaction improved.

In 2001, ACS launched a pilot program funded by the Agency for Healthcare Research and Quality (AHRQ) to show that NSQIP was also effective in private-sector hospitals. Based on the successful pilot, in 2004 ACS began enrolling new private sector hospitals into NSQIP.
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Original Investigation

Association of Hospital Participation in a Quality Reporting Program With Surgical Outcomes and Expenditures for Medicare Beneficiaries

Nicholas H. Osborne, MD, MS; Lauren H. Nicholas, PhD; Andrew M. Ryan, PhD; Jyothi R. Thumma, MPH; Justin B. Dimick, MD, MPH
Discussion

In this study, we analyzed approximately 345,000 hospitalizations occurring at NSQIP vs non-NSQIP hospitals. Approximately half were performed in hospitals that participated in the NSQIP, and our methods were focused on understanding the association between participation in NSQIP and changes in rates of postoperative outcomes. Our study found that rates of inpatient complications, serious complications, and mortality during the 2 years after the NSQIP implementation in 2005 were lower at NSQIP hospitals than did non-NSQIP hospitals, represented in a higher level of likelihood of complications (adjusted odds ratio, 0.98; 95% CI, 0.94-1.03), or mortality (0.7% for NSQIP vs 1.0% for non-NSQIP hospitals; unadjusted risk difference, 0.16%; 95% CI, 0.19%-0.39%) were lower for patients treated at NSQIP hospitals than non-NSQIP hospitals, with NSQIP hospitals had improvements in outcomes during the same period. The difference-in-differences model used in our study explicitly accounts for underlying temporal trends in surgical outcomes. Also, NSQIP hospitals provided care to sicker patients than non-NSQIP hospitals, represented in a higher Medicare Case Mix Index. Several differences between the current study and the study by Hall et al did not account for the possibility that non-NSQIP hospitals in several aspects. NSQIP hospitals were different from non-NSQIP hospitals in several aspects. NSQIP hospitals in terms of likelihood of complications (adjusted odds ratio, 1.04; 95% CI, 0.94-1.14) 

These findings differ from earlier work investigating the association between participation in NSQIP and hospital performance and may represent a somewhat different spectrum of cases restricted to include only elective operations and complications that occurred within the index hospitalization. The rates of inpatient complications, serious complications, and mortality were lower at NSQIP hospitals over time in a way that is different than in non-NSQIP hospitals. Also, NSQIP hospitals provided care to sicker patients than did non-NSQIP hospitals, represented in a higher Medicare Case Mix Index. These findings differ from earlier work investigating the association between participation in NSQIP and hospital performance and may represent a somewhat different spectrum of cases restricted to include only elective operations and complications that occurred within the index hospitalization. The rates of inpatient complications, serious complications, and mortality were lower at NSQIP hospitals over time in a way that is different than in non-NSQIP hospitals.

**Figure 2. Adjusted Rates of Complications, Serious Complications, and Mortality by Hospital NSQIP Participation and Year**

<table>
<thead>
<tr>
<th>Year</th>
<th>NSQIP</th>
<th>Non-NSQIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NSQIP, National Surgical Quality Improvement Program. Error bars indicate 95% CIs. Adjusted for patient comorbidity, operation type, age, and sex.
"Weighing a pig does not make the pig fatter"
DATA

without

DATA

without

ANALYTICS

= \emptyset
ANALYTICS without = Ø

OPERATIONALIZING & IMPLEMENTING YOUR FINDINGS
Machine Learning Predictions of Post-operative Length of Stay

Selected Patient Metadata

<table>
<thead>
<tr>
<th>PATIENT</th>
<th>AGE</th>
<th>SEX</th>
<th>RACE</th>
<th>BMI</th>
<th>FXSTATUS</th>
<th>ASA</th>
<th>PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4b20e14</td>
<td>65</td>
<td>FEMALE</td>
<td>WHITE OR CAUCASIAN</td>
<td>30.8</td>
<td>Independent</td>
<td>3</td>
<td>APR</td>
</tr>
</tbody>
</table>

Showing 1 to 1 of 1 entries

Selected Patient Validation Predictions

Web Application & Machine Learning Coded by:
Enrck S. Huang, MD, PhD
ERAS Principal Investigator:
Julie Thacker, MD

Thanks to Dr. Mohamed Adam & Caitlin Daley for data contributions

APPLIED MACHINE LEARNING IN SURGERY
Machine Learning Predictions of Post-operative Length of Stay

Predictive Models of Extended Length of Stay

Select a patient from the queue using the drag menu above. When you release, the web application will generate a range of predictions for the patient based on several predictive models.

Click on the tabs to see other visualizations or analyses.

For the model “neighborhood”, 25 random test splits of the data were performed. Using the “Random Forest” ensemble machine learning method, we generate 25 models that each “see” something different about the full cohort and thereby create a range of predictions for each patient—a neighborhood. No machine learning method is perfect: so by training multiple models on different cuts of the patient cohort you are inducing real world variability. If the range of predictions for a particular patient is tight, we have reasonable confidence that the predictions are reliable. If they are widely dispersed, this is indicative of uncertainty in the predictions.

The features on which the models are trained include demographics, surgeon, BMI, pre-op labs, operative variables, laparoscopic vs. open, diagnoses, year of procedure, functional status, among others.

In this web application, for each patient selected, some metadata is displayed in the upper panel while their out-of-sample predictions are plotted above a density function plot of the cumulative “landscape” of predictions for all patients across the entire neighborhood of models.

Web Application & Machine Learning Coded by:
Erin S. Huang, MD, PhD

ERAS Principal Investigator:
Julie Thacker, MD

Thanks to Dr. Mohamed Adam & Caitlin Daley for data contributions

APPLIED MACHINE LEARNING IN SURGERY
select a patient
select a patient

multiple models make a prediction about LOS
select a patient

multiple models make a prediction about LOS

X-axis is probability of length of stay > 5 days
Machine Learning Predictions of Post-operative Length of Stay

Select a patient: 4b20e14

Multiple models make a prediction about LOS

Density plot of the "landscape" of predictions for all patients

X-axis is probability of length of stay > 5 days
Direct Hospital Cost versus Length of Stay

$7,716,547
Total Cost for ERAS Cohort

$1744
Mean LOS

2 Day Reduction in LOS cuts Direct Hospital Costs 1/3rd
DHI, BMSF DDC, and CMS-HCIA SEDI

A trio of projects supporting a platform for monitoring and evaluating population health through spatially-enabled data architecture and analytics
“Moving the Needle on Diabetes”

• Durham Health Innovations (DHI): Original partnership, 2009
• BMS Foundation and the Durham Diabetes Coalition, 2011
• Center for Medicare-Medicaid Services (CMS) Healthcare Innovations Awards and the Southeastern Diabetes Initiative, 2012
Figure 1  Overlap of diabetes cohorts identified from different categories of phenotype eligibility criteria; n=24 520 patients identified by criteria from any of the three categories.