Supplementary Online Content


**eTable.** *International Classification of Diseases, Ninth Revision (ICD-9), Procedure Codes Used to Determine Complications and Reoperations*

**eFigure.** An overview of the empirical approach

**eStatistical Methods**

This supplementary material has been provided by the authors to give readers additional information about their work.
**eTable. International Classification of Diseases, Ninth Revision (ICD-9), Procedure Codes Used to Determine Complications and Reoperations**

<table>
<thead>
<tr>
<th>Complication</th>
<th>ICD-9 Procedure Codes</th>
</tr>
</thead>
</table>
| Unexpected reoperations for surgical complications | Wound dehiscence 54.61  
Removal of foreign body 54.92  
Laparotomy 54.12 |
| Splenic                                   | Injury 41.2  
Partial or complete splenectomy 41.43, 41.5 |
| Hemorrhagic                               | Intraoperative hemorrhage 998.11  
Postoperative hematoma 998.12  
Blood transfusion 99.04, 99.09 |
| Anastomotic                               | Leak 998.6  
Percutaneous abdominal drainage 54.91 |
| Wound                                     | Infection 998.5, 998.51, 998.59  
Seroma 998.13  
Dehiscence 998.3 |
| Obstruction                               | Small bowel obstruction 560.0-560.9 |
| Pulmonary                                 | Respiratory tract complications 997.3  
Acute bacterial pneumonia 481, 482.0-482.9, 485, 486  
Acute respiratory failure 518.81  
Tracheotomy 31.1, 31.29 |
| Cardiac                                   | Complications 997.1  
Acute myocardial infarction 410.0-410.9 |
| Neurological                              | Central nervous system complications 997.01-997.03  
Acute cerebrovascular accident 431.00-431.91, 433.00-433.91, 434.00-434.91, 436, 437.1 |
| Genitourinary tract                       | Urinary tract complications 997.5  
Acute renal failure 584.1-584.9  
Acute dialysis 38.95  
Insertion of short-term dialysis catheter 39.95 |
| Thromboembolic                            | Acute pulmonary embolism 415.1, 415.11, 415.19  
Acute deep venous thrombosis 453.8, 453.9 |
| Shock                                     | Postoperative 998.0 |
| Reoperations                              | Reopening of recent laparotomy, 5412  
Exploratory laparotomy (performed after primary surgery, 5411 |
<table>
<thead>
<tr>
<th>Procedure Type</th>
<th>ICD-9 Procedure Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reclosure of dehiscence</td>
<td>Reclosure of disrupted abdominal wound, 5471</td>
</tr>
<tr>
<td>Management of postoperative shock/hemorrhage</td>
<td>Control of hemorrhage, 3998, 4995, 5793, 6094, 3941, 3998 Splenectomy, 415</td>
</tr>
<tr>
<td>Retrieval of Retained Foreign Body</td>
<td>Removal of foreign body from peritoneal cavity, 5492 Removal of foreign body, not otherwise specified, 9820</td>
</tr>
<tr>
<td>Reoperation for management of deep surgical site infection</td>
<td>Drainage abdominal wall or retroperitoneal abscess, 540 Laparotomy drainage of abscess/hematoma, 5419 Other operations on intestine; revision of anastomosis of large intestine, 4694</td>
</tr>
<tr>
<td>Repair of an organ injury/laceration</td>
<td>Excision of small intestine, 4461 Suture of duodenal, small intestine, large intestine or rectum laceration, 4671, 4673, 4675, 4871 Suture of liver laceration, 5061</td>
</tr>
</tbody>
</table>

Complication codes were derived from Santry HP et al. Trends in bariatric surgical procedures. *JAMA*. 2005;294:1909-1917. Serious complications were defined as any of the *ICD-9* codes and a length of stay greater than or equal to 5 days.
eFigure. An overview of the empirical approach

- **Pre-NCD**
- **Post-NCD**

**Complication Rate**

- **National Coverage Decision**

- **Hypothetical improvement in Medicare safety if pre-NCD trend continued**

- **DID Effect of NCD:** Additional improvement in Medicare relative to Non-Medicare

- **Effect of Common Time Trend**
eStatistical Methods

We estimated difference-in-differences models to test for causal effects of the National Coverage Decision (NCD) on the quality of bariatric surgery provided to Medicare beneficiaries. This method uses data from Medicare and non-Medicare patients before and after the coverage decision to control for improvements in the quality of bariatric surgery for all patients occurring over time and differential improvement in care provided to Medicare beneficiaries that would have happened regardless of the NCD. Failure to account for these existing trends could cause us to overstate the impact of the NCD.

This approach compares the change in complication rates among Medicare beneficiaries after the NCD to the change in complication rates among non-Medicare patients. The changes among non-Medicare patients represent the improvements in safety expected to occur regardless of the NCD as surgery became safer over time. Our regression models account for permanent differences between Medicare and non-Medicare patients, differences in outcomes for all patients in the post vs. pre-period, and the treatment effect of the NCD, the interaction of Medicare status and post-period. For patient outcomes $Y_{it}$, the basic models estimate patient-level regressions

$$Y_{it} = \alpha_{Med} + \beta_{Post} + \delta_{Med} \times Post + \epsilon_{it} \quad (1)$$

where $t=$ the time period, $i=0$ represents nonmedicare patients, $i=1$ for medicare patients for variable Med, Post=0 pre-COE and post=1 in the post-COE era, epsilon is the error term and $\delta$ can be interpreted as the causal effect of the NCD on the safety of bariatric surgery if there are no significant differences in trend among Medicare and non-Medicare patients before the intervention and if the intervention only impacted Medicare patients.

We reject the null hypothesis of no difference in trend for complications, but not reoperations. Prior to the NCD, complication rates were already declining more rapidly for Medicare patients ($p < 0.01$). Thus, we modify Equation (1) to include a separate linear time trend for Medicare patients, Medicare*Time, where time is a continuous measure of study quarter (1 – 28) in the complications regressions. We also control for patient demographics and Elixhauser comorbidities, $X_{it}$, and calendar year dummies, CY to model time trends.

Our main specifications for all and serious complications are logistic regression models

$$Y_{it} = \alpha_{Med} + \beta_{Post} + \delta_{Med} \times Post + \theta X_{it} + \gamma_{Med} \times Time_{i} + CY + \epsilon_{it} \quad (2)$$

Since there is no difference in reoperation trends in the pre-period ($p = 0.13$), the reoperation models are estimated as

$$Y_{it} = \alpha_{Med} + \beta_{Post} + \delta_{Med} \times Post + \theta X_{it} + CY + \epsilon_{it} \quad (3).$$

All models are estimated with robust standard errors clustered at the hospital level to account for hospital-level autocorrelation and heteroskedasticity.

The causal interpretation of $\delta$ is supported by regression models indicating that the NCD had no effect on the safety of care provided to non-Medicare beneficiaries. If the NCD
had an independent effect on care provided to all patients, non-Medicare patients would not be a valid control group. We address this concern by estimating

\[ Y_{it} = \beta \text{Post}_{it} + \theta \text{X}_{it} + \text{CY} + \varepsilon_{it} \]  

for non-Medicare patients only. As reported in the main text, \( \beta \) is substantively and statistically indistinguishable from an odds ratio of 1, indicating that there was no impact of the NCD on non-Medicare patients and supporting their use as a control group.