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# A Decade Analysis of Trends and Outcomes of Bariatric Surgery in Medicare Beneficiaries



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- BACKGROUND:** In 2006, the Centers for Medicare and Medicaid Services issued a National Coverage Determination (NCD), which mandates that bariatric procedures be performed only at accredited centers. The aim of this study was to analyze outcomes of Medicare beneficiaries who underwent bariatric surgery before (2001 through 2005) vs after (2006 through 2010) implementation of the NCD.
- STUDY DESIGN:** The Nationwide Inpatient Sample database was used to analyze data on patients who underwent bariatric surgery between 2001 and 2010. Main outcomes measures were demographics, length of stay, risk-adjusted inpatient morbidity and mortality, and cost.
- RESULTS:** There were 775,040 patients who underwent bariatric surgery, with 16% of the patients Medicare beneficiaries. There was an overall trend for improved in-hospital mortality during the decade (0.35% in 2001 to 0.10% in 2010). Medicare patients who underwent bariatric surgery had higher rates of comorbidities and a higher rate of in-hospital mortality than non-Medicare patients. After the NCD, there was a significant reduction of the in-hospital mortality (0.56% vs 0.23%;  $p < 0.01$ ) and serious morbidity (9.92% vs 6.98%;  $p < 0.01$ ) for Medicare patients and a similar reduction of the in-hospital mortality (0.18% vs 0.08%;  $p < 0.01$ ) and serious morbidity (6.84% vs 5.08%;  $p < 0.01$ ) for non-Medicare patients. Compared with patients who underwent stapling bariatric procedures at accredited centers, patients at nonaccredited centers had higher risk-adjusted in-hospital mortality (odds ratio = 3.53; 95% CI, 1.01–6.52) and serious morbidity (odds ratio = 1.18; 95% CI, 1.07–1.30). After the NCD, use of bariatric surgery within Medicare beneficiaries increased by 71%.
- CONCLUSIONS:** Outcomes of bariatric surgery in Medicare beneficiaries have improved substantially since the 2006 NCD. Facility accreditation appears to be a contributing factor to the observed improvement in outcomes. (J Am Coll Surg 2014;219:480–488. © 2014 by the American College of Surgeons)
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The Centers for Medicare and Medicaid Services (CMS) is currently providing care for an estimated 50.8 million Medicare beneficiaries, comprising approximately 16% of

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the US population.<sup>1</sup> In September 2013, CMS overturned a component of its 2006 National Coverage Determination (NCD), which limited bariatric surgery to centers accredited by the American College of Surgeons or the American Society for Metabolic and Bariatric Surgery. The criteria for accreditation currently includes a threshold yearly procedure volume, experienced surgeons who specialize in bariatric surgery, trained ancillary staff, a multidisciplinary team, and having appropriate equipment to accommodate morbidly obese patients. A reversal of the facility certification decision was made despite ample evidence showing improved outcomes after the NCD without impeding access to care for the Medicare beneficiaries.<sup>2–6</sup> The recent CMS decision to forgo facility accreditation requirement will now allow Medicare patients to undergo bariatric surgery at

**Abbreviations and Acronyms**

CMS = Centers for Medicare and Medicaid Services  
NCD = National Coverage Determination  
NIS = Nationwide Inpatient Sample  
OR = odds ratio

any facility without regard for the center's commitment to care for bariatric surgery patients, availability of appropriate equipment and trained staff, or having requisite case-volume experience. This decision might place Medicare patients undergoing bariatric surgery at risk for higher morbidity and mortality rates. The aim of this study was to analyze the outcomes of bariatric surgery at a national level for both Medicare and non-Medicare patients who underwent bariatric surgery before vs after the NCD was issued. Additionally, we aimed to understand the impact of accreditation on outcomes by examining the outcomes of non-Medicare patients who underwent bariatric surgery after the NCD at accredited vs nonaccredited centers. Lastly, we aimed to analyze the use of bariatric surgery by Medicare beneficiaries before vs after the NCD to determine if there are any barriers to obtaining access to bariatric surgical care.

**METHODS****Database**

The Nationwide Inpatient Sample (NIS) database is the largest all-payer inpatient care database currently available in the United States. It contains information on approximately 8 million hospital stays per year from 1,000 hospitals across the country. The large sample size enables analysis of specific patient populations and procedures. The NIS data approximate a 20% stratified sample of US community, nonmilitary, and nonfederal hospitals, which provides a sampling frame that represents roughly 95% of all hospital discharges in the nation. Inpatient data are collected from hospital discharge abstracts and billing records that contain patient demographics, inpatient procedures, hospital length of stay, morbidity, in-hospital mortality, and hospital charges. Approval for the use of the NIS patient-level data in this study was obtained from the Institutional Review Board of the University of California Irvine Medical Center and from the Healthcare Cost and Utilization Project.

**Selection and description of participants**

Using the NIS database from 2001 through 2010, we identified all morbidly obese patients undergoing elective admission for bariatric surgery. Appropriate diagnosis and procedural codes were selected using the ICD-9-CM.

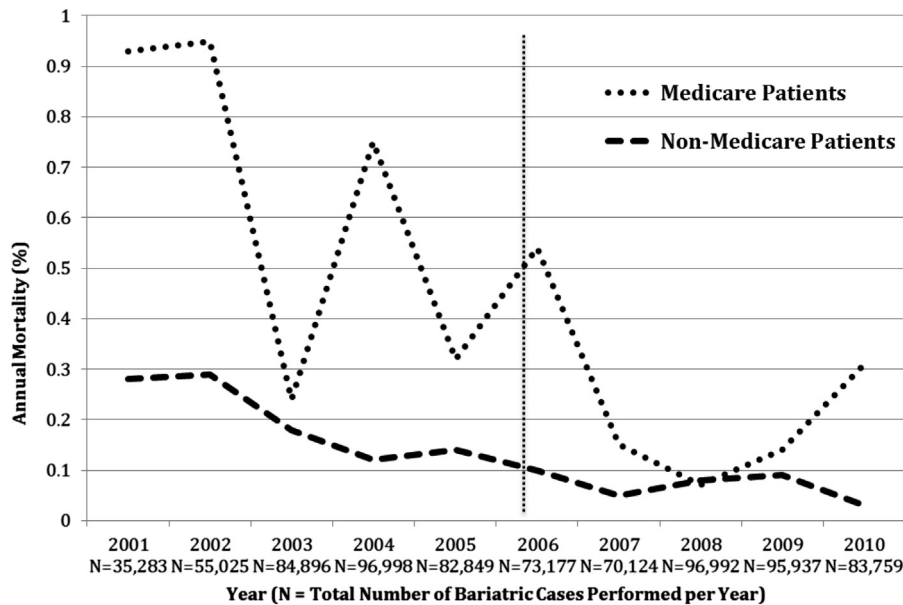
Principle diagnosis codes used were obesity and morbid obesity (278.0, 278.00, and 278.01). The ICD-9 procedural codes included laparoscopic gastric banding (44.95), laparoscopic sleeve gastrectomy (43.82 and 44.68), laparoscopic Roux-en-Y gastric bypass (44.38), and open Roux-en-Y gastric bypass (44.31 and 44.39). Patients who underwent emergent procedures were excluded from analysis.

The cohort was first divided by payer type: "Medicare" (Medicare and Medicaid) compared with "non-Medicare" (private and other payers) patients. Medicare represents coverage for people 65 years of age and older or those younger than 65 years with a disability. Individuals who received both Medicare and Medicaid were included in our analysis because many beneficiaries are dual eligible.

Trends of in-hospital mortality were analyzed by year, comparing Medicare vs non-Medicare patients who underwent bariatric surgery between 2001 and 2010. The number of bariatric procedures performed among Medicare beneficiaries was analyzed by year for 2001 through 2010. Outcomes of Medicare and non-Medicare patients who underwent bariatric surgery before vs after the NCD were analyzed. The period before the NCD was defined as 2001 through 2005 and the period after the NCD was defined as 2006 through 2010. Lastly, a subgroup analysis was performed examining the outcomes of non-Medicare patients who underwent stapling bariatric procedures (gastric bypass or gastric sleeve) after the 2006 NCD (2006 through 2010) performed at accredited vs nonaccredited centers. Accredited centers were identified according to the CMS website listing for facility certification. Specific American hospital association codes within the NIS were used to categorize accredited and nonaccredited facilities.

**Outcomes variables**

Patient demographics (age, sex, and ethnicity), comorbidities, and outcomes were compared based on Medicare vs non-Medicare payer status, time period, and hospital accreditation status. Any missing demographic data were excluded from analysis. Primary outcomes measures included rate of in-hospital mortality and serious morbidity. In-hospital mortality rate was defined as the percentage of patients who died before being discharged from the hospital. The NIS database does not include information on deaths that occurred after discharge or on hospital readmission. Serious morbidity was defined as anastomotic leak, sepsis, pulmonary empyema/abscess, acute renal failure, acute respiratory failure, cardiac complications, cerebrovascular accidents, deep venous thrombosis, and wound complications. Secondary outcomes measures were length of hospital stay, specific complications, and mean hospital charges.



**Figure 1.** Annual mortality rate for Medicare and non-Medicare patients who underwent bariatric surgery before and after the 2006 national coverage determination (dashed vertical line).

### Statistical analysis

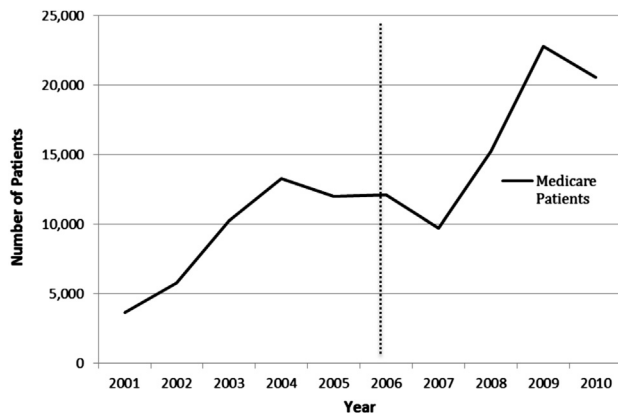
Statistical analysis was performed using SAS software version 9.3 (SAS Institute) and the R statistical environment. Analyses were performed with raw numbers and weighted to reflect national averages. Differences in patient characteristics, complications, and in-hospital mortality between groups were analyzed. Binary outcomes were compared using chi-square tests with Yates correction. Continuous variables were compared using 2-sample *t*-tests with unequal variance.

Multivariate logistic regression analysis was performed for in-hospital morbidity and mortality to compare risk-adjusted outcomes for Medicare patients who underwent bariatric surgery before vs after the NCD. Independent variables used for risk adjustment included demographics (age, sex, and ethnicity), comorbidities (congestive heart failure, chronic pulmonary disease, diabetes, hypertension, liver disease, peripheral vascular disorders, and renal failure), and procedural type. Risk-adjusted morbidity and mortality rates were also calculated in non-Medicare patients who underwent stapling bariatric procedures at accredited vs nonaccredited centers from 2006 through 2010. Robust standard errors were used for inference to guard against model misspecification and Holm's method was used to account for multiple comparisons between adjusted *p* values.<sup>7,8</sup> Comparisons were considered statistically significant if the *p* value was <0.05. All reported *p* values are 2-sided.

### RESULTS

A total of 775,040 patients were sampled from the NIS database between 2001 and 2010, with Medicare and Medicaid beneficiaries constituting 16% of all cases. The yearly in-hospital mortality for Medicare vs non-Medicare patients is depicted in Figure 1. There was a trend in reduction of in-hospital mortality rate over time for both Medicare and non-Medicare patients. The in-hospital mortality rate for Medicare patients who underwent bariatric surgery decreased from 0.93% in 2001 to 0.31% in 2010. The in-hospital mortality rate for non-Medicare patients similarly decreased from 0.28% in 2001 to 0.03% in 2010. Figure 2 shows the estimated number of Medicare patients who underwent bariatric surgery each year between 2001 and 2010 with the dashed line representing the year of implementation of the NCD.

Patient demographics and comorbidities were compared between Medicare and non-Medicare patients who underwent bariatric surgery (Table 1); mean age was higher in Medicare patients (46 vs 43 years, respectively; *p* < 0.01). The Medicare group, compared with the non-Medicare group, had a higher proportion of Hispanics (10.8% vs 6.0%, respectively; *p* < 0.01) and African American patients (16.9% vs 12.0%, respectively; *p* < 0.01). Medicare patients had higher rates of comorbidities compared with non-Medicare patients. The largest mean differences were noted for



**Figure 2.** Annual number of Medicare patients undergoing bariatric surgery before vs after the 2006 national coverage determination (dashed vertical line).

chronic pulmonary disease (25.3% vs 15.3%, respectively;  $p < 0.01$ ), diabetes (40.5% vs 26.0%, respectively;  $p < 0.01$ ), and hypertension (58.7% vs 49.1%, respectively;  $p < 0.01$ ). The overall Van Walraven/Elixhauser comorbidity score was also higher in Medicare compared with non-Medicare patients (2 vs 1, respectively;  $p < 0.01$ ).<sup>9</sup>

Table 2 depicts the demographic characteristics and outcomes for Medicare patients who underwent bariatric surgery before (2001 through 2005) vs after (2006 through 2010) the NCD. There were more Hispanic Medicare patients undergoing bariatric surgery after the NCD. Medicare patients who underwent bariatric surgery after the NCD had higher rates of comorbidities, including chronic pulmonary disease, diabetes, and hypertension. Compared with before the NCD (2001 through 2005), Medicare patients who underwent bariatric surgery after the NCD had shorter length of hospital stay (4 vs 3 days, respectively;  $p < 0.01$ ), lower serious morbidity (9.92% vs 6.98%, respectively;  $p < 0.01$ ), and lower in-hospital mortality (0.56% vs 0.23%, respectively;  $p < 0.01$ ). A multivariate analysis of Medicare patients who underwent bariatric surgery after the NCD was performed as a reference (Table 3). Medicare patients who underwent bariatric surgery before the NCD had higher rates of risk-adjusted in-hospital mortality (odds ratio [OR] = 2.32; 95% CI, 1.49–3.70;  $p < 0.01$ ) and serious morbidity (OR = 1.25; 95% CI, 1.13–1.39;  $p < 0.01$ ).

Outcomes for non-Medicare patients who underwent bariatric surgery before vs after the NCD are depicted in Table 4. Compared with before the NCD (2001 through 2005), non-Medicare patients who underwent bariatric surgery after the NCD had shorter length of hospital stay (3 vs 2 days, respectively,  $p < 0.01$ ), lower

**Table 1.** Patient Demographics and Comorbidities for Medicare vs Non-Medicare Patients, 2001 Through 2010

	Medicare (n = 125,322)	Non-Medicare (n = 649,718)	p Value
Age, y, mean	46*	43	<0.01
Sex, %			
Male	19.3*	18.8	<0.01
Female	80.7	81.2	0.10
Race or ethnicity, %			
White	68.8*	77.6	<0.01
Black	16.9*	12.0	<0.01
Hispanic	10.8*	6.0	<0.01
Asian or Pacific Islander	0.2*	0.5	<0.01
Native American	0.3*	0.5	<0.01
Other	2.9*	3.4	<0.01
Comorbidities			
Comorbidity score	2*	1	<0.01
Congestive heart failure, %	4.20*	1.0	<0.01
Chronic pulmonary disease, %	25.30*	15.30	<0.01
Diabetes, %	40.50*	26.0	<0.01
Hypertension, %	58.70*	49.10	<0.01
Liver disease, %	8.70*	8.0	<0.01
Peripheral vascular disorder, %	0.90*	0.40	<0.01
Renal failure, %	1.90*	0.50	<0.01

\*p Value <0.05 compared with non-Medicare.

serious morbidity (6.84% vs 5.08%, respectively;  $p < 0.01$ ), and lower in-hospital mortality (0.18% vs 0.08%, respectively,  $p < 0.01$ ).

A subset analysis was performed to examine outcomes of non-Medicare patients who underwent stapling bariatric procedures (gastric sleeve and gastric bypass) after the NCD at accredited vs nonaccredited centers (Table 5). Patients who underwent bariatric surgery at accredited centers had higher rates of comorbidities, including chronic pulmonary disease, diabetes, hypertension, and renal failure. Compared with patients who underwent bariatric surgery at nonaccredited centers, patients who underwent bariatric surgery at accredited centers had a shorter length of hospital stay (mean difference of –1 day;  $p < 0.01$ ) and lower serious morbidity (5.93% vs 6.73%, respectively;  $p < 0.01$ ) and in-hospital mortality (0.06% vs 0.21%, respectively;  $p < 0.01$ ). A multivariate analysis comparing outcomes at nonaccredited vs accredited centers is depicted in Table 3. Using accredited centers as a reference, nonaccredited centers had higher rates of in-hospital mortality (OR = 3.53; 95% CI, 1.91–6.52;  $p < 0.01$ ) and serious complications (OR = 1.18; 95% CI, 1.07–1.30;  $p < 0.01$ ).

**Table 2.** Patient Demographics, Comorbidities, and Outcomes for Medicare Patients Who Underwent Bariatric Surgery Before (2001 Through 2005) vs After (2006 Through 2010) the 2006 National Coverage Determination

Patient characteristics	Medicare, 2001–2005 (n = 46,210)	Medicare, 2006–2010 (n = 79,005)	p Value
Age, y, mean ± SD	45 ± 12*	48 ± 14	<0.01
Sex, %			
Male	17.3*	20.4	<0.01
Female	82.7*	79.6	<0.01
Race or ethnicity, %			
White	69.8*	68.2	<0.01
Black	16.9	17.0	0.89
Hispanic	10.1*	11.1	0.02
Asian or Pacific Islander	0.1*	0.3	<0.01
Native American	0.3	0.4	0.28
Other	2.8	3.0	0.40
Comorbidities			
Comorbidity score, mean ± SD	2 ± 4	2 ± 5	1
Congestive heart failure, %	4.36	4.18	0.51
Chronic pulmonary disease, %	23.2*	26.52	<0.01
Diabetes, %	34.12*	44.16	<0.01
Hypertension, %	50.44*	63.45	<0.01
Liver disease, %	7.02*	9.70	<0.01
Peripheral vascular disorders, %	0.71*	0.97	0.04
Renal failure, %	0.88*	2.49	<0.01
Outcomes			
Length of stay, d	4*	3	<0.01
In-hospital mortality, %	0.56*	0.23	<0.01
Serious morbidity, %	9.92*	6.98	<0.01
Anastomotic leak, %	2.34*	1.69	0.04
Sepsis, %	0.41	0.45	0.73
Wound complications, %	1.53*	0.66	<0.01
Ileus, %	0.88	1.03	0.25
Bowel obstruction, %	0.06	0.11	0.39
Urinary tract infection, %	1.42*	0.89	<0.01
Pneumonia, %	1.16*	0.59	<0.01
Respiratory failure, %	3.42*	1.34	<0.01
Acute renal failure, %	2.46	2.37	0.69
Cardiac complications, %	1.33*	0.89	<0.01
CVA, %	0.01	<0.01	0.79
DVT, %	0.09	0.08	0.91
Postoperative bleeding, %	1.66	1.46	0.25
Total charge, \$, mean ± SD	33,152 ± 36,903*	39,486 ± 38,530	<0.01

\*p Value <0.05 compared with Medicare 2001 through 2005.

DVT, deep vein thrombosis.

## DISCUSSION

Facility accreditation for Medicare patients undergoing bariatric surgery has been a subject of much debate during the past year. Despite opposition from the American College of Surgeons and American Society for Metabolic and Bariatric Surgery, the CMS recently overturned a component of its NCD that limits coverage of bariatric surgery

to procedures performed at accredited hospitals. Our current study provides additional data to substantiate the clinical benefit of facility certification. First, there was a significant reduction of in-hospital mortality for Medicare beneficiaries who underwent bariatric surgery after the NCD (0.56% vs 0.23%, respectively). Second, since the NCD, access to obtain care does not appear to be

**Table 3.** Risk-Adjusted In-Hospital Mortality and Serious Complications for Medicare Patients Who Underwent Bariatric Surgery Before vs After (Reference) the 2006 National Coverage Determination and for Non-Medicare Patients Who Underwent Stapling Bariatric Procedures (Sleeve Gastrectomy and Gastric Bypass) at Nonaccredited vs Accredited Centers (Reference), 2006 Through 2010

	Adjusted OR (95% CI)	Naïve p Value	Adjusted p Value
Before vs after (reference)			
NCD			
In-hospital mortality	2.32 (1.49–3.7)	<0.01	<0.01
Serious complications	1.25 (1.13–1.39)	<0.01	<0.01
Nonaccredited vs accredited (reference)			
In-hospital mortality	3.53 (1.91–6.52)	<0.01	<0.01
Serious complications	1.18 (1.07–1.30)	<0.01	0.02

NCD, National Coverage Determination; OR, odds ratio.

an issue as the number of bariatric procedures performed in Medicare beneficiaries increased by 71% after the NCD. Additionally, access to care for bariatric surgery by race was not impacted by the NCD. Lastly, an analysis on the impact of accreditation shows improvements in in-hospital mortality and serious morbidity when bariatric surgery was performed at accredited compared with nonaccredited centers.

The main finding of the current study is the improved outcomes in Medicare beneficiaries after implementation of the NCD, with a 59% reduction in in-hospital

mortality. Using the nationwide Medicare data, Flum and colleagues similarly reported the 90-day mortality decreased from 1.5% pre-NCD to 0.7% post-NCD.<sup>5</sup> In contrast, Dimick and colleagues analyzed outcomes of Medicare vs non-Medicare patients who underwent bariatric surgery before vs after implementation of the NCD using a difference-in-differences statistical approach that used the non-Medicare patients as a control group.<sup>10</sup> They concluded that there was no significant difference in the rates of complications and reoperation before vs after the CMS policy. However, their assumption that non-Medicare patients can be used as a control group is flawed. By 2006, it was estimated that up to 85% of centers in the United States had facility certification, and, therefore, the accreditation process already had an impact on the majority of non-Medicare patients.<sup>2</sup> Another major flaw in their study is the omission of mortality data analysis because mortality is the most accurate data point that can be obtained from administrative data.

Another argument against facility certification involves possibly restricting access for Medicare beneficiaries.<sup>11</sup> Our study actually showed improved access, with a 71% increase in procedural volume in the first 5 years after the NCD compared with before the NCD. Other studies have similarly reported a temporary decrease in case volume immediately after the NCD that corrected within a year of NCD implementation.<sup>3,5</sup> In a contrary study, Livingston and Burchell reported that the median distance traveled before the NCD was 16 to 25 miles,

**Table 4.** Outcomes for Non-Medicare Patients Who Underwent Bariatric Surgery Before (2001 Through 2005) vs After (2006 Through 2010) the 2006 National Coverage Determination

	Non-Medicare, 2001–2005 (n = 320,840)	Non-Medicare, 2006–2010 (n = 338,975)	p Value
Length of stay, d, mean ± SD	3 ± 4*	2 ± 3	<0.01
In-hospital mortality, %	0.18*	0.08	<0.01
Serious morbidity, %	6.84*	5.08	<0.01
Anastomotic leak, %	0*	0.11	<0.01
Sepsis, %	0.1*	0.23	<0.01
Wound complications, %	0.81*	0.43	<0.01
Ileus, %	0.84	0.90	0.25
Bowel obstruction, %	0.12	0.12	0.98
Urinary tract infection, %	0.67*	0.56	<0.01
Pneumonia, %	0.74*	0.42	<0.01
Respiratory failure, %	2.12*	0.72	<0.01
Acute renal failure, %	1.15	1.13	0.75
Cardiac complications, %	0.85*	0.67	<0.01
CVA, %	0.01*	0.00	0.03
DVT, %	0.02*	0.05	<0.01
Postoperative bleeding, %	1.46*	1.27	<0.01
Total charge, \$, mean ± SD	29,603 ± 26,836*	36,311 ± 28,130	<0.01

\*p Value <0.05 compared with Medicare 2001 through 2005.

DVT, deep vein thrombosis.



**Table 5.** Patient Demographics and Comorbidities for Non-Medicare Patients Who Underwent Stapling Bariatric Procedures at Accredited vs Nonaccredited Centers, 2006 Through 2010

	Accredited (n = 220,455)	Nonaccredited (n = 38,635)	p Value
Age, y, mean $\pm$ SD	44 $\pm$ 11*	43 $\pm$ 11	<0.01
Sex, %			
Male	20.3*	21.4	0.03
Female	79.7*	78.6	0.03
Race or ethnicity, %			
White	75.9	75.9	0.96
Black	12.4*	14.3	<0.01
Hispanic	5.8*	6.9	<0.01
Asian or Pacific Islander	0.5	0.3	0.05
Native American	0.8*	0.5	<0.01
Other	4.6*	2.1	<0.01
Comorbidities			
Comorbidity score, mean $\pm$ SD	1 $\pm$ 4	1 $\pm$ 4	1
Congestive heart failure, %	1.01	0.94	0.62
Chronic pulmonary disease, %	17.95*	15.63	<0.01
Diabetes, %	32.23*	30.57	<0.01
Hypertension, %	57.2*	52.96	<0.01
Liver disease, %	11.42*	8.37	<0.01
Peripheral vascular disorders, %	0.51	0.52	0.97
Renal failure, %	0.83*	0.56	<0.01
Outcomes			
Length of stay, d, mean $\pm$ SD	2 $\pm$ 3*	3 $\pm$ 4	<0.01
In-hospital mortality, %	0.06*	0.21	<0.01
Serious morbidity, %	5.93*	6.73	<0.01
Anastomotic leak, %	2	2.28	0.12
Intra-operative abscess, %	0.15	0.13	0.82
Sepsis, %	0.27	0.32	0.50
Wound complications, %	0.54	0.54	0.95
Ileus, %	1.09	1.35	0.06
Bowel obstruction, %	0.14	0.23	0.09
Urinary tract infection, %	0.64	0.74	0.34
Pneumonia, %	0.48*	0.69	0.02
Respiratory failure, %	0.76*	1.40	<0.01
Acute renal failure, %	1.29	1.36	0.64
Cardiac complications, %	0.76	0.80	0.76
CVA, %	<0.01	0.00	0.55
DVT, %	0.06	0.04	0.72
Postoperative bleeding, %	1.57	1.49	0.62
Total charge, \$, mean $\pm$ SD	38,398 $\pm$ 30,031	38,780 $\pm$ 33,092	0.31

\*p Value <0.05, compared with accredited.

DVT, deep vein thrombosis.

which drastically increased to 44 miles after the NCD.<sup>11</sup> The authors concluded that the Centers of Excellence process leads to reduced access. However, the authors failed to acknowledge that patients who traveled a long distance to obtain care at their medical center actually bypassed one or sometimes several other accredited

centers to obtain care specifically at University of Texas Southwestern Medical Center. This finding might represent a personal preference of certain patients to obtain care at their desired institution rather than the inability to obtain care within their local region due to the lack of accredited facility. In another study, Nicholas and



Dimick reported reduced access for minority patients undergoing bariatric surgery after the NCD.<sup>2,12</sup> Using a difference-in-differences analysis, they found a 4.7% point reduction in nonwhite patients undergoing bariatric surgery after the NCD. Their findings are in contrast to our current results, which found an increase in minority patients undergoing bariatric surgery after the NCD, specifically Hispanics and Asians/Pacific islanders.

To better understand the impact of accreditation on outcomes, we examined the non-Medicare patients who underwent bariatric surgery at accredited vs nonaccredited centers after implementation of the NCD (Fig. 1). Compared with accredited centers, nonaccredited centers were associated with higher risk-adjusted rates of in-hospital mortality (OR = 3.53;  $p < 0.01$ ) and serious morbidity (OR = 1.18;  $p < 0.01$ ). Our result is in agreement with data reported from academic centers that have shown significantly lower in-hospital mortality at accredited vs nonaccredited centers (0.06% vs 0.21%, respectively).<sup>2</sup> In contrast, Livingston reported similar in-hospital mortality rates between accredited vs nonaccredited centers (0.17% vs 0.09%, respectively); however, his study used the 2005 NIS database. The main limitation of that study is that in 2005, the accreditation process was in its infancy and still evolving.<sup>13</sup> In 2005, only 24 (9.5%) of 253 centers were considered to be accredited facilities.<sup>13</sup> It is worth noting that when evaluating the impact of accreditation, it is important to do so at a time period when the majority of centers have been accredited. Premature analysis can lead to a false-negative finding.

This study does have some limitations. The observational nature of the dataset could be affected by certain confounding variables during the study period. There was an increase in use of laparoscopic surgery during the decade, with the rate of laparoscopic bariatric surgery exceeding that of open bariatric surgery in 2005.<sup>14</sup> Laparoscopic bariatric surgery has been shown consistently to improve outcomes compared with open bariatric surgery. The national volume of bariatric surgery also increased during the study period. The resulting development of surgeon expertise and experience might have led to some of the observed improvement in outcomes. Increased use of laparoscopic adjustable gastric banding might also explain some of the improvement in outcomes. Additional limitations are related to the NIS database, which contains only inpatient data and cannot account for any morbidity or mortality that might have occurred after discharge. Therefore, the in-hospital mortality might underestimate the "true" mortality. Serious complications can also be vague and subjectively defined due to the fact that NIS

data are compiled from coding of hospital discharge abstracts and billing records. The designation for accreditation was based on the most current CMS-accredited hospital listing and applied throughout the period of 2006 through 2010, which might lead to an inaccurate designation of centers during a particular year. Despite these limitations, this study examined a large representative sample of both Medicare and non-Medicare patients who underwent bariatric surgery before vs after the NCD in an effort to understand the impact of accreditation on outcomes.

## CONCLUSIONS

Outcomes of bariatric surgery in Medicare beneficiaries have improved substantially since implementation of the 2006 NCD. Similarly, outcomes of bariatric surgery in non-Medicare patients have improved after the NCD, likely due to the high rate of acceptance of the accreditation process. Facility accreditation was associated with improved outcomes. Institution of the 2006 NCD was associated with an increase in use of bariatric surgery by Medicare beneficiaries without impeding access to care in minority patients.

## Author Contributions

Study conception and design: Jafari, Gebhart, Nguyen

Acquisition of data: Young, Phelan

Analysis and interpretation of data: Young, Phelan

Drafting of manuscript: Young, Jafari, Gebhart

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