ORIGINAL ARTICLE

Impact of Bariatric Surgery on Health Care Costs of Obese Persons

A 6-Year Follow-up of Surgical and Comparison Cohorts Using Health Plan Data

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Importance: Bariatric surgery is a well-documented treatment for obesity, but there are uncertainties about the degree to which such surgery is associated with health care cost reductions that are sustained over time.

Objective: To provide a comprehensive, multiyear analysis of health care costs by type of procedure within a large cohort of privately insured persons who underwent bariatric surgery compared with a matched nonsurgical cohort.

Design: Longitudinal analysis of 2002-2008 claims data comparing a bariatric surgery cohort with a matched nonsurgical cohort.

Setting: Seven BlueCross BlueShield health insurance plans with a total enrollment of more than 18 million persons.

Participants: A total of 29 820 plan members who underwent bariatric surgery between January 1, 2002, and December 31, 2008, and a 1:1 matched comparison group of persons not undergoing surgery but with diagnoses closely associated with obesity.

Main Outcome Measures: Standardized costs (overall and by type of care) and adjusted ratios of the surgical group's costs relative to those of the comparison group.

Results: Total costs were greater in the bariatric surgery group during the second and third years following surgery but were similar in the later years. However, the bariatric group's prescription and office visit costs were lower and their inpatient costs were higher. Those undergoing laparoscopic surgery had lower costs in the first few years after surgery, but these differences did not persist.

Conclusions and Relevance: Bariatric surgery does not reduce overall health care costs in the long term. Also, there is no evidence that any one type of surgery is more likely to reduce long-term health care costs. To assess the value of bariatric surgery, future studies should focus on the potential benefit of improved health and well-being of persons undergoing the procedure rather than on cost savings.

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OBESITY IS A SIGNIFICANT burden on the US health care system. An estimated $168 billion—16.5% of US health expenditures—is spent annually to treat obesity and obesity-associated comorbid conditions.[1] Bariatric surgery is a well-documented treatment for obesity that leads to considerable weight loss and health improvement.[2-4]

Studies on the impact of bariatric surgery on a person's future health care costs have shown mixed results. Several studies showed decreases in health care expenditures.[5-9] Some studies have suggested that there may be a return on investment in 3 to 7 years.[5,6,8] Two recent follow-up studies that matched cases and controls based on body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) were not able to identify overall cost or health care utilization savings over time associated with surgical intervention, although drug costs appeared lower.[10,11]

See Invited Critique at end of article

Because of its potential to improve health and reduce costs, bariatric surgery is covered by many public and commercial health insurance plans, although coverage terms vary. The number of bariatric surgical procedures performed annually has been increasing, with an estimated 220 000 procedures performed in the United States in 2009.[12] In particular, laparoscopic approaches have been increasing in popularity owing to shorter hospital stays and lower complication rates.[13]

However, many uncertainties remain about whether and when a return on investment can be expected, which type of bariatric surgical procedure produces the greatest cost reduction, and whether cost reductions are sustained over time.

The aim of this study was to provide a comprehensive, multiyear analysis of health care costs in a large cohort of privately insured persons who underwent bariatric surgery compared with a matched nonsurgical cohort. Also, within the surgical group, we assessed patterns of cost over time by type of surgical procedure.

METHODS

STUDY SUBJECTS AND COMPARISON GROUP

Researchers at The Johns Hopkins University collaborated on this study with 7 BlueCross BlueShield health insurance plans in 7 states. These health plans covered approximately 18 million persons at the onset of our study; during the study period, the plans offered coverage for bariatric surgery for obesity treatment according to clinical guidelines (ie, BMI ≥35 with an obesity-related comorbidity or BMI ≥40).[14]

The 7 plans provided The Johns Hopkins University with insurance claims (medical and pharmacy) and enrollment data on a sample of 48 741 individuals who underwent bariatric surgery. To be eligible for inclusion in the surgery group, enrollees had to be aged 18 years or older, have a bariatric surgery claim between January 1, 2002, and December 31, 2008, and be enrolled in the health plan for at least 6 months before and after the surgery date. The *Current Procedural Terminology* (*CPT*), *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*), and diagnosis related group codes used for initial selection of the surgery group are listed in eTable 1 (http://www.jamasurg.com).

We also obtained data for 4 275 974 plan members who did not undergo bariatric surgery but had been diagnosed as having obesity, hyperlipidemia, diabetes mellitus, sleep apnea, metabolic syndrome, and/or gallbladder disease. The *CPT*, *ICD-9-CM*, and National Drug Code codes used to identify individuals who were eligible for inclusion in the comparison group are also listed in eTable 1.

From this base group, we developed a final comparison group using a 1:1 matching process with each member of the surgical cohort. To do this, we considered insurance enrollment characteristics and 33 condition markers derived from claims diagnoses or medication use that were statistically linked with a BMI of 35 or higher within a sample of 71 000 BlueCross BlueShield members for whom we had BMI data. The obesity propensity scoring method we applied is described in detail in a previous article.[15] In addition to matching within deciles of the propensity score, we also did a 1:1 match on age, sex, presence of prescription drug coverage, and plan location. A detailed overview of the selection process is presented in eFigure 1.

The Johns Hopkins Bloomberg School of Public Health Institutional Review Board reviewed and approved the study.

DATA COLLECTION AND MEASURES

The BlueCross BlueShield plans provided the following: (1) enrollment files; (2) benefits information indicating medical and pharmacy coverage; and (3) adjudicated inpatient, outpatient, and pharmacy claims. Five plans provided these data for a 4-year period (January 1, 2002, to December 31, 2005) and 2 plans provided these data for a 7-year period (January 1, 2002, to December 31, 2008). The latter 2 plans accounted for 70% of the bariatric surgery sample.

Age, sex, and number of months of medical and pharmacy coverage were measured using enrollment data.

Surgical *CPT* codes and diagnosis related groups were used to identify bariatric surgical procedures. We classified bariatric surgical procedures into 1 of the following 5 categories: laparoscopic banding, laparoscopic gastric bypass, open gastric bypass, other restrictive, and unknown (11% of our surgical sample had an inpatient claim diagnosis related group for bariatric surgery but no *CPT* code to identify the surgery type, and we categorized such cases as unknown type of surgery; gastrectomy procedures [0.3% of the sample] were also classified as unknown). The *CPT* codes used to assign each surgery patient into these 5 categories are listed in eTable 2.

Costs were determined using the medical and pharmacy claims. In addition to total costs, we developed several subcategories based on type of service codes: (1) inpatient, which includes both inpatient facility and physician claims; (2) physician and other independent professional services provided in an office setting; (3) pharmacy costs, based on paid prescriptions filled in retail pharmacies; and (4) all other claims for noninpatient services (eg, laboratory, imaging). When feasible, we standardized charges across plans and across study years using the average Medicare relative value units payment amount in 2005. When this was not feasible, we used actual allowed charges. For pharmacy claims, we used paid charges. Further details on how we standardized costs are provided in eTable 3.

Costs were calculated for the following periods: the operative period (or index period for the comparison group [comparison group members were assigned an index date equivalent to the date of surgery for their matched counterpart]), defined as the bariatric surgery hospitalization period (or day of outpatient surgery); the 30-day postoperative period, defined as 30 days after the operative/index period; the preoperative/preindex period, defined as the 365 days prior to the operative/index period; and postoperative/postindex periods 1 through 6, defined as the six 365-day periods following the 30-day postoperative/postindex period.

STATISTICAL ANALYSIS

Two sets of analyses were performed. The first set compared costs for the surgery group with costs for the comparison group. The second set compared costs by surgery type within the surgery group only. Standardized cost served as the dependent variable in both sets of analyses. Persons with no costs during a study year were assigned a cost of $1.

For the first set of analyses, we applied a multivariate statistical method that accounted for the matching design and adjusted for any remaining differences between the 2 cohorts. We adjusted for the following factors: (1) age; (2) obesity propensity score during the preoperative/preindex period; and (3) 32 markers indicating the presence or absence of a wide range of morbidities (not just obesity related) during the preoperative/preindex period. These markers were based on the aggregated diagnosis group clusters of the widely used Johns Hopkins Adjusted Clinical Group case-mix classification system that categorizes every *ICD* code into clinically cogent categories (Adjusted Clinical Group case-mix system software version 9.0; http://www.acg.jhsph.edu; The Johns Hopkins University).

In addition to the 3 variables already mentioned, we adjusted for sex, the health plan in which the person was enrolled, and the specific surgery/index year.

Finally, to account for remaining unmeasured differences between the surgery and comparison groups, we included as a covariate each person's total costs in the 12 months prior to the sur-

Table 1. Sizes of Surgery Group by Surgery Type and Duration of Observation Period[a]

Surgery Type	Patients in Postoperative Observation Period, No. (%)					
	1 y	2 y	3 y	4 y	5 y	6 y
Open gastric bypass	10 550 (35.4)	7854 (40.2)	6007 (47.1)	4283 (56.6)	3046 (66.45)	1384 (71.4)
Laparoscopic gastric bypass	11 419 (38.3)	7153 (36.6)	4121 (32.3)	1793 (23.7)	724 (15.8)	217 (11.9)
Laparoscopic banding	3678 (12.3)	1632 (8.3)	655 (5.1)	264 (3.5)	21 (0.5)	0
Other restrictive surgery	959 (3.2)	642 (3.3)	455 (3.6)	261 (3.5)	189 (4.12)	110 (5.7)
Unknown[b]	3214 (10.8)	2283 (11.7)	1522 (11.9)	970 (12.8)	604 (13.2)	228 (11.8)
Total	**29 820 (100)**	**19 564 (100)**	**12 760 (100)**	**7571 (100)**	**4584 (100)**	**1939 (100)**

[a] Among the 7 collaborating plans, 2 submitted data for 2002 to 2008 and the other 5 submitted data for 2002 to 2005.
[b] Unknown includes those who had a gastrectomy procedure code *and* an inpatient diagnosis related group code for obesity surgery as well as those whose procedures could not be identified from physician claims data but who had an inpatient admission diagnosis related group indicating that they underwent surgery for obesity.

gery/index date. This statistical approach compares each study member's change in cost during this period with their own starting point, similar to a difference-in-difference analysis. Including preoperative/preindex costs as a covariate is preferred because it allows the coefficient to be any number, whereas a difference-in-difference model assumes the coefficient to be 1.

We used generalized log-gamma regressions to calculate the ratio of the mean costs for the surgery group to the mean costs for the comparison group. A person's membership in the surgery group served as the main independent variable and the comparison group served as the reference.

Generalized log-gamma regressions were also performed for the second set of analyses comparing mean costs over time by surgery type. Study members who underwent open gastric bypass served as the reference.

RESULTS

Table 1 summarizes the number of bariatric surgery patients meeting the inclusion criteria and for whom we were able to identify a matched control.Table 1 presents counts by type of surgery and by length of time the study members were enrolled in the health plan. The final surgical cohort included 29 820 persons undergoing surgery who were enrolled for at least 6 months of the preoperative period and postoperative period. As expected for a study based on health plan enrollment, the size of the surgical cohort decreases with each postoperative/postindex period.

Table 2 displays the characteristics of the surgery and comparison groups. Overall, the 2 groups were well matched. The surgical cohort and comparison group were perfectly matched based on age, sex, coverage, and obesity propensity score percentile rankings (based on 33 obesity-linked morbidity markers in the preoperative/preindex period). Five of these 33 morbidity markers are presented in Table 2, and they suggest that during the preoperative/preindex period, the surgery group included somewhat more individuals diagnosed as having hypertension during this period and the comparison group included somewhat more individuals with diabetes. (Note that additional case-mix adjustment was performed after matching to help control for any remaining morbidity differences between the cases and controls.)

Table 2. Characteristics of Surgery and Comparison Groups

Characteristic	%, Surgery (n = 29 820)	%, Comparison (n = 29 820)
Sex		
Male	19.4	19.4
Female	80.6	80.6
Age at surgery/index year, y		
18-29	7.1	7.1
30-44	36.7	36.7
45-64	54.4	54.4
≥65	1.8	1.8
Mean (SD)	45.5 (10.4)	47.0 (11.5)
Estimated obesity score percentiles based on all health plan enrollees[a]		
≤50th	8.0	8.0
51st-74th	9.0	9.0
75th-89th	9.0	9.0
90th-94th	19.0	19.0
95th-99th	27.0	27.0
>99th	28.0	28.0
Medical coverage duration in operative/index year, mo		
6-11	16.3	16.3
12	83.7	83.7
Pharmacy coverage during operative/index year		
Yes	75.8	75.8
No	24.2	24.2
Select morbidities diagnosed during operative/index year[b]		
Hypertension	54.7	45.9
Type 2 diabetes mellitus	24.6	30.9
Cardiovascular disorder, other	4.9	3.1
Cerebrovascular disease	2.0	2.7
Peripheral vascular disease	0.5	1.0

[a] These estimates are based on an obesity propensity score calculated during the preoperative/preindex year using 33 disease markers that were statistically linked to having a body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) of 35 or higher. The percentile distribution of this obesity percentile estimate (ie, the likelihood of having a BMI ≥35) is based on a representative sample of study site plan members with comparable scores for whom we had BMI information.[15]
[b] The propensity model we used included 33 disease markers that go beyond just these 5. Also, additional case-mix adjustment was performed during analyses.

eTable 4 presents trends in bariatric surgical procedure types across each study period. Surgery trends shifted over time, with 72% of surgical procedures in 2002 being open gastric bypass and with laparoscopic surgery becoming dominant in 2005. The percentage of unknown

Table 3. Mean Standardized, Unadjusted Costs for Surgery and Comparison Groups Over Time by Expenditure Category

Expenditure Category and Group	Cost for Each Period, Mean (SD), $[a]								
	1-y PRE	Operative/ Index	30-d POST	POST, y 1	POST, y 2	POST, y 3	POST, y 4	POST, y 5	POST, y 6
Total									
Surgery	8850 (12 542)	27 833 (12 479)	1684 (6107)	8905 (18 814)	9908 (19 273)	9211 (19 263)	9051 (19 520)	9386 (21 137)	9259 (26 909)
Comparison	9590 (21 913)	154 (1291)	850 (3832)	9908 (22 192)	9264 (21 057)	9041 (21 243)	9232 (19 819)	8966 (20 270)	8714 (27 280)
Inpatient[b]									
Surgery	2227 (9025)	26 814 (13 306)	1146 (5722)	4193 (15 512)	5186 (15 935)	4666 (16 045)	4171 (15 766)	4302 (16 979)	4407 (23 166)
Comparison	4271 (18 341)	67 (1194)	375 (3506)	4378 (17 908)	3817 (16 635)	3720 (17 519)	3768 (14 915)	3602 (16 013)	3612 (24 366)
Professional office[b]									
Surgery	1814 (1924)	160 (774)	78 (252)	1176 (2418)	1212 (2654)	1163 (2286)	1262 (2612)	1299 (2821)	1251 (2849)
Comparison	1284 (2343)	22 (168)	113 (386)	1301 (2570)	1285 (3111)	1254 (3183)	1310 (3925)	1226 (2211)	1155 (2421)
Outpatient and other[b]									
Surgery	3001 (4342)	783 (2646)	322 (1109)	2304 (4335)	2286 (4508)	2099 (4534)	2161 (5049)	2295 (6043)	2233 (6081)
Comparison	2148 (5145)	34 (275)	187 (853)	2191 (5841)	2118 (6297)	2034 (5930)	2087 (5951)	2070 (5534)	2068 (6148)
Pharmacy									
Surgery	1809 (3329)	76 (187)	137 (330)	1232 (3622)	1223 (3062)	1283 (2971)	1456 (3476)	1491 (3051)	1368 (2855)
Comparison	1888 (3603)	31 (155)	175 (403)	2038 (3909)	2044 (3705)	2032 (3647)	2067 (3625)	2068 (4110)	1878 (3684)

Abbreviations: POST, postoperative/postindex; PRE, preoperative/preindex.

[a] Costs are based on 2005 US dollars standardized across all plans. Costs have been annualized for partial-year enrollees. No statistical adjustments have been made. The 30-day POST period includes 30 days after the admission/index date. The POST period 1 started on the 31st day after the admission/index date. Each POST year included 365 days from that starting point. Likewise, the PRE year included the 365 days before the admission/index date. Individuals had to be enrolled for at least half of each period to be included in each year's findings.

[b] Inpatient costs include both institution and professional fees for services provided on an inpatient basis. Professional office costs include all ambulatory services billed by physicians and other independent professionals. Outpatient and other costs include services billed by outpatient departments of hospitals and all other types of ambulatory service providers (eg, laboratories).

type of surgery decreased dramatically after 2004 owing to the introduction of *CPT* codes specifically for laparoscopic bariatric surgery.

Table 3 presents mean standardized costs by category for the surgery and comparison groups for the preoperative/preindex period, the operative/index period, the 30-day postoperative/postindex period, and postoperative/postindex periods 1 through 6 (eFigure 2 graphically depicts these data). The total costs for the 2 groups were within 8% of each other during the preoperative/preindex period (surgery, $8850; comparison, $9590), which suggests that the groups were reasonably well matched, even before statistical adjustments were applied. (The comparison group's costs were likely higher in the preoperative/preindex period owing to the fact that these individuals were selected because they were being actively treated for an obesity-related diagnosis during this year, while the surgical group was selected because they underwent surgery in a later period. We adjusted for this differential starting point through statistical analysis.)

Among the surgery cohort, the standardized total cost of the surgical episode for all types of bariatric surgery combined was $29 517 (data not shown). This included the costs of both the surgical admission ($27 833) and the 30-day follow-up period ($1684).

Total costs among the surgical group peaked in the second year after surgery and then leveled off. In no postoperative period did they decrease below the overall annual costs observed in the preoperative period. The comparison group's costs decreased slightly after postindex period 1, likely owing to a regression toward the mean effect.

Some notable findings emerge when these unadjusted costs are examined by subcategory. For the surgical cohort, there was approximately a 30% decrease in pharmacy costs during the 3 years following surgery. There is some increase in subsequent years, but this likely was because we were unable to adjust for pharmacy unit cost inflation—about 2% to 3% per year—as we did for all other services. There was no such decrease in pharmacy costs in the comparison group.

Even though the surgical cohort had lower inpatient costs than the comparison group during the preoperative/preindex period, inpatient costs increased significantly after bariatric surgery, peaking in postoperative periods 2 and 3. A closer examination of the types of inpatient admissions (by diagnosis related group) showed that the surgical group had significantly more admissions for digestive-related diagnoses in all 6 postoperative periods relative to the comparison group. A significant proportion of these admissions were likely for follow-up procedures for bariatric surgery–related complications. In contrast, the comparison group had higher admission rates for cardiovascular- and respiratory-related conditions or procedures throughout the study period. A separate study using this same database presents these findings.[16]

The **Figure** presents ratios of the surgical group's costs relative to the comparison group by period and cost categories, after making a series of multivariate adjustments and accounting for each individual's starting point. Ratios greater than 1 indicate that the surgical cohort's costs were higher than those of the comparison group. Numeric results for these findings are shown in eTable 5.

The adjusted total expenditures for bariatric surgery patients were comparable to those for the matched comparison group, except in postoperative/postindex periods 2 and 3, when the surgical group's total costs were slightly higher than those of the comparison group (by 16% and 7%, respectively). Among the 4 cost subcategories, inpatient costs were significantly higher for the surgical group relative to the comparison group. In con-

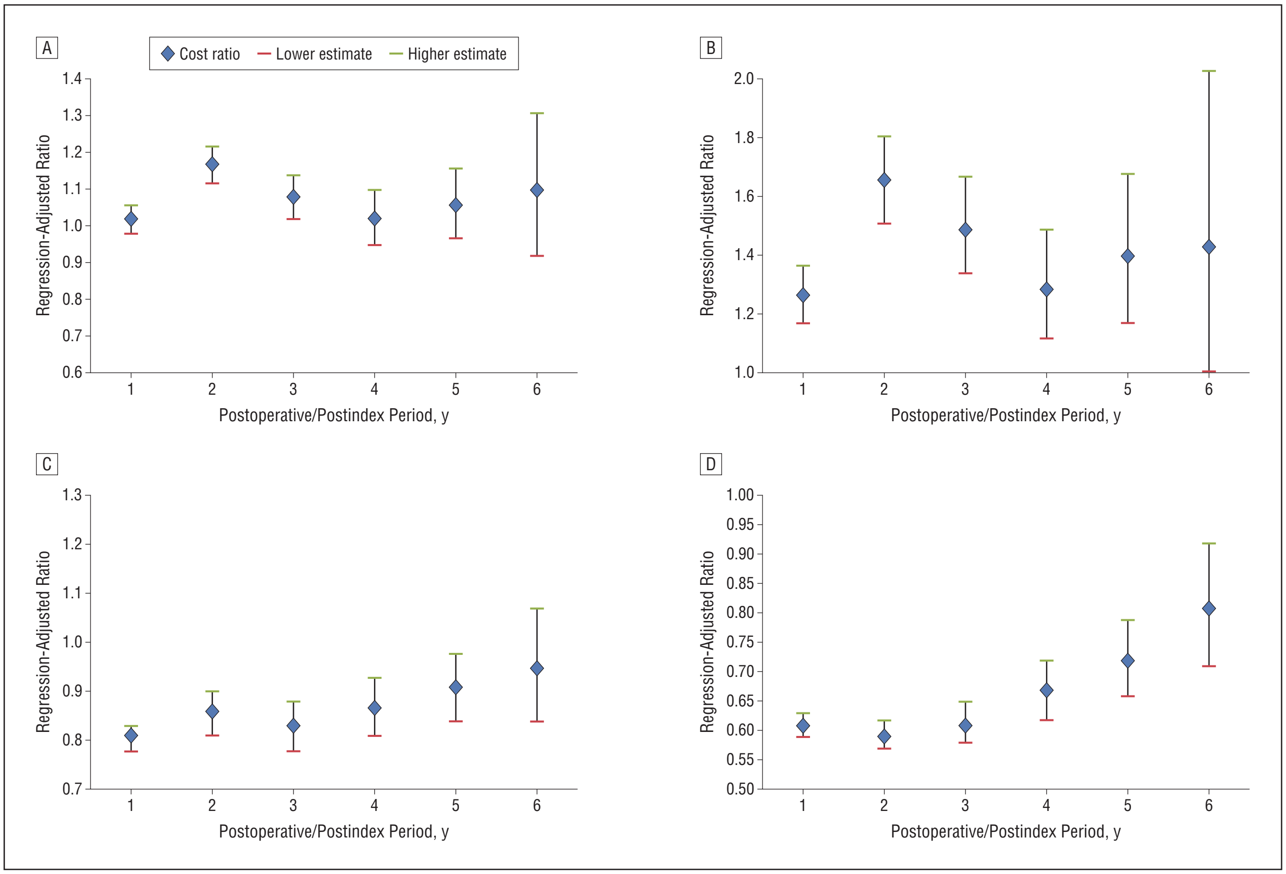

Figure. Regression-adjusted ratios of surgery group costs to comparison group costs by time and expenditure category, including total cost (A), inpatient cost (B), professional office cost (C), and pharmacy cost (D). Ratios higher than 1.00 indicate that the annual costs are greater among the surgical cohort compared with the comparison group for that period. Ratios in which the 95% CI does not cross 1.00 are statistically significant at the $P = .05$ level. This analysis adjusted for the matching design of the study and the following covariates: person's baseline cost in the preoperative/preindex period, age, obesity propensity score during the preoperative/preindex period, and 32 morbidity groups (aggregated diagnosis groups) based on all diagnoses found in the claims during the preoperative/preindex year. Total cost includes inpatient, professional office, outpatient/other, and pharmacy costs.

trast, except for professional office costs in postoperative/postindex period 6, the pharmacy and office costs were significantly lower for the surgery group.

Table 4 presents regression-adjusted cost ratios by type of surgery, with open gastric bypass as the reference group. eTable 6 presents the raw unadjusted costs within the surgical cohort by type of procedure for each period and expenditure category. Total costs in postoperative periods 1 and 2 for patients who underwent laparoscopic banding were significantly lower than those who underwent open gastric bypass, but these differences did not persist in subsequent periods. A similar pattern is observed with the patients who underwent laparoscopic gastric bypass, due largely to lower inpatient costs observed during these periods. However, this aspect of the analysis has limited statistical power owing to the diminishing years of follow-up data available for these newer procedures.

In contrast, office visit costs in the first 4 years after surgery were greater for patients who underwent laparoscopic banding than for those who underwent open gastric bypass. Similar patterns were not observed for patients who underwent laparoscopic gastric bypass.

Pharmacy costs were significantly greater among patients who underwent laparoscopic banding than those who underwent open gastric bypass, but only for the first year after surgery. Similar ratios were not observed with the patients who underwent laparoscopic gastric bypass until 3 to 5 years after surgery.

COMMENT

A major finding of this study is that overall health care resource use among obese individuals undergoing bariatric surgery is relatively stable during the 6 years following surgery. When these individuals' health care costs are compared with those of a matched comparison group, total costs are significantly greater in the surgical cohort in the second and third years following surgery, but overall costs of those undergoing surgery are not lower than those of the matched comparison group during follow-up years 4 through 6. A closer examination of these results reveals an interesting finding: the surgery group experienced substantial decreases in costs for both filled prescriptions and office-based visits during the postoperative years compared with the preoperative baseline, but this was offset by significant increases in inpatient services.

This study also provides a detailed breakdown of postsurgery health care costs by the type of bariatric procedure performed. As others have documented, certain types of surgery (ie, laparoscopic banding and laparoscopic bypass) are associated with lower costs after surgery. How-

Table 4. Regression-Adjusted Ratios of Standardized Costs by Type of Surgery

Expenditure Type[a]	Surgery Type	Cost Ratio (95% CI) of Postoperative Period[b] 1 y	2 y	3 y	4 y	5 y	6 y
Total	Open gastric bypass	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
	Laparoscopic banding	0.78 (0.74-0.82)	0.85 (0.78-0.93)	0.96 (0.84-1.09)	1.15 (0.95-1.39)	1.40 (0.73-2.67)	NA
	Laparoscopic gastric bypass	0.90 (0.86-0.94)	0.85 (0.81-0.90)	0.88 (0.82-0.95)	0.97 (0.88-1.07)	1.10 (0.95-1.26)	1.14 (0.89-1.46)
	Other restrictive surgery	1.04 (0.96-1.14)	0.98 (0.87-1.10)	1.14 (0.98-1.31)	1.57 (1.31-1.90)	1.35 (1.07-1.69)	2.04 (1.47-2.83)
	Unknown[c]	1.04 (0.98-1.09)	0.81 (0.76-0.87)	0.91 (0.84-0.99)	1.08 (0.97-1.20)	1.05 (0.92-1.21)	1.09 (0.86-1.38)
Inpatient	Open gastric bypass	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
	Laparoscopic banding	0.53 (0.46-0.60)	0.67 (0.57-0.80)	0.80 (0.62-1.03)	1.32 (0.90-1.93)	1.73 (0.47-6.41)	NA
	Laparoscopic gastric bypass	0.79 (0.72-0.87)	0.75 (0.67-0.84)	0.77 (0.66-0.88)	0.84 (0.69-1.02)	0.96 (0.71-1.29)	1.34 (0.80-2.22)
	Other restrictive surgery	1.05 (0.86-1.27)	0.88 (0.70-1.12)	1.17 (0.89-1.55)	2.15 (1.48-3.13)	1.36 (0.84-2.18)	3.13 (1.68-5.83)
	Unknown[c]	1.06 (0.94-1.19)	0.75 (0.65-0.86)	0.84 (0.71-1.00)	1.08 (0.87-1.34)	0.96 (0.72-1.26)	1.15 (0.71-1.87)
Professional office	Open gastric bypass	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
	Laparoscopic banding	1.32 (1.25-1.39)	1.25 (1.15-1.35)	1.46 (1.29-1.64)	1.25 (1.04-1.51)	1.78 (0.94-3.37)	NA
	Laparoscopic gastric bypass	1.00 (0.97-1.04)	1.04 (0.98-1.09)	1.04 (0.97-1.11)	1.06 (0.96-1.17)	1.07 (0.93-1.22)	1.15 (0.90-1.48)
	Other restrictive surgery	1.09 (1.02-1.18)	1.13 (1.01-1.26)	1.05 (0.92-1.21)	1.34 (1.11-1.60)	1.26 (1.01-1.57)	1.29 (0.94-1.77)
	Unknown[c]	1.02 (0.98-1.07)	0.90 (0.85-0.96)	1.01 (0.93-1.10)	1.06 (0.95-1.17)	1.12 (0.98-1.28)	1.12 (0.88-1.42)
Outpatient and other	Open gastric bypass	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
	Laparoscopic banding	0.82 (0.77-0.87)	0.89 (0.80-0.98)	1.00 (0.87-1.16)	1.06 (0.85-1.33)	1.14 (0.53-2.48)	NA
	Laparoscopic gastric bypass	0.96 (0.92-1.01)	0.92 (0.86-0.98)	0.95 (0.87-1.02)	1.05 (0.93-1.17)	0.95 (0.81-1.12)	1.01 (0.74-1.38)
	Other restrictive surgery	1.09 (0.99-1.20)	1.10 (0.96-1.26)	1.11 (0.95-1.31)	1.23 (0.99-1.53)	1.21 (0.93-1.57)	1.69 (0.15-2.47)
	Unknown[c]	0.95 (0.90-1.01)	0.80 (0.74-0.87)	0.92 (0.83-1.01)	1.07 (0.94-1.21)	1.09 (0.93-1.28)	1.21 (0.91-1.60)
Pharmacy	Open gastric bypass	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
	Laparoscopic banding	1.16 (1.08-1.25)	1.02 (0.91-1.14)	1.04 (0.89-1.23)	0.99 (0.77-1.28)	0.83 (0.35-1.96)	NA
	Laparoscopic gastric bypass	1.05 (0.99-1.10)	0.98 (0.91-1.06)	1.12 (1.02-1.23)	1.18 (1.04-1.34)	1.39 (1.17-1.65)	1.27 (0.92-1.75)
	Other restrictive surgery	1.20 (1.07-1.34)	1.12 (0.96-1.29)	1.12 (0.93-1.35)	1.26 (0.99-1.62)	1.62 (1.20-2.18)	1.24 (0.82-1.89)
	Unknown[c]	1.13 (1.06-1.21)	1.05 (0.97-1.15)	1.10 (0.98-1.23)	1.32 (1.14-1.53)	1.39 (1.15-1.67)	1.14 (0.83-1.55)

Abbreviation: NA, not applicable.

[a] Inpatient costs include both institution and professional fees for services provided on an inpatient basis. Professional office costs include all ambulatory services billed by physicians and other independent professionals. Outpatient and other costs include services billed by outpatient departments of hospitals and all other types of ambulatory service providers (eg, laboratories).

[b] The following covariates were included in the model: cost in the preoperative period, sex, age, obesity propensity score during the preoperative period, full- or partial-year enrollment, presence of pharmacy coverage, health plan indicator, operative year, and 32 aggregated diagnosis groups based on all health care provider–assigned diagnoses in the preoperative period. Ratios higher than 1.00 with a 95% CI that does not include 1.00 indicate that individuals who underwent that type of surgery had costs significantly (at the $P = .05$ level) greater than those who underwent open gastric bypass. Ratios lower than 1.00 with a 95% CI that does not include 1.00 indicate that individuals who underwent that type of surgery had costs significantly less than those who underwent open gastric bypass.

[c] Unknown includes those who had a gastrectomy procedure code *and* an inpatient diagnosis related group code for obesity surgery as well as those whose procedures could not be identified from physician claims data but who had an inpatient admission diagnosis related group indicating that they underwent surgery for obesity.

ever, our study confirms this finding only for a limited period. Our results show that there are cost savings associated with both types of laparoscopic surgery relative to the open gastric bypass procedure for the first 2 to 3 years following surgery owing to decreased inpatient costs. However, these savings do not persist into later years. Moreover, there is some indication (although not statistically significant) that open gastric bypass was associated with lower overall health care costs compared with laparoscopic bypass procedures during the fifth and sixth years following surgery.

Our study has several limitations. First, while the population from which the sample was drawn was large and diverse, the results may not be generalizable to those older than 65 years or those without private insurance (eg, uninsured or Medicaid). Second, while we went to great lengths to select a carefully matched comparison group and used advanced statistical approaches to control for potential postmatch confounders, it is possible that unmeasured sources of bias were present. Third, especially in early years, some laparoscopic surgical procedures may have been misclassified as open procedures and some laparoscopic cases may have been converted to open surgery midway through the procedure. Fourth, due to the shifting patterns of surgical type during the study period, the study group for each postoperative year represented a different mix of surgery type. Fifth, while insurance claims data are commonly used for such cost-focused research, some of our data may have been inaccurate or incomplete. However, such data flaws should be constant across the surgical and comparison cohorts and are unlikely to affect the internal validity of the study.

This study adds substantially to the existing literature on cost of bariatric surgery in several important ways. First, to our knowledge, the sample is the largest cohort to date of bariatric surgery cases followed up over time, and the types of cases represent the wide range of procedures performed. Many previous studies focused on only certain types of surgery[8,17-24] or did not distinguish among the different types of procedures.[6,9-12] Second, the sample is representative of a broad cross-section of the commercially insured US population, unlike 2 other recent studies, one of which focused on 847 (mostly male) patients within the US Department of Veterans Affairs health care system[11] and the other on 2010 Swedish patients undergoing surgery between 1987 and 2001.[10] Third, this study has one of the longest follow-up periods reported in a US study. The periods for previous studies generally have been limited to 6 months to 2 years following bariatric surgery, with most of the longer-term studies being performed with data from outside the United States or in a specialized setting.[6,9-11] Fourth, the analyses were conducted using data from the relatively recent period of 2002 to 2008, while many previous cost studies used data from 2002 or earlier, when laparoscopic and banding procedures were less common.[6,9,10,17-20,25-29] Fifth, in addition to very carefully documenting health care cost trends of a large bariatric surgery cohort (something of considerable interest on its own), we provide a point of reference by comparing this group's costs with those of a comparison cohort matched using a series of innovative approaches. Most previous cost studies did not include a comparison or control group to contrast what the costs would have been had surgery not been performed.[8,12,14,17-31] Sixth, our large and detailed health insurance database allowed us to perform an in-depth assessment of expenditures. Many earlier studies reported only total costs[7,28,31] or examined only specific bariatric-related cost categories[17,18,25,26,29,30] or prescription drug costs and use.[17,18,21,25,26,29,30]

The cost of bariatric surgery is significant, more than $28 000 (in 2005 US dollars) within our cohort. During a 6-year follow-up period of this privately insured cohort, we were unable to identify any short- or long-term reductions in overall health care costs associated with surgery. This study, along with 2 other recent studies focused on total health care costs,[10,11] suggests that to assess the value of bariatric surgery, future studies should focus on the potential benefit of improved health and well-being of persons undergoing the procedure rather than on cost savings.

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Author Contributions: Drs Weiner and Chang and Mr Richards had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Weiner, Goodwin, Chang, Bolen, Johns, Momin, and Clark. *Acquisition of data:* Weiner, Goodwin, Momin, and Clark. *Analysis and interpretation of data:* Weiner, Goodwin, Chang, Bolen, Richards, Johns, Momin, and Clark. *Drafting of the manuscript:* Weiner, Goodwin, Richards, and Johns. *Critical revision of the manuscript for important intellectual content:* Weiner, Goodwin, Chang, Bolen, Johns, Momin, and Clark. *Statistical analysis:* Goodwin, Chang, and Richards. *Obtained funding:* Weiner, Goodwin, Momin, and Clark. *Administrative, technical, and material support:* Weiner, Goodwin, Bolen, Johns, Momin, and Clark. *Study supervision:* Weiner and Bolen.
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INVITED CRITIQUE

Is Bariatric Surgery Worth It?

Is bariatric surgery worth it? Maybe not. Accumulating evidence suggests there is no economic benefit for weight loss surgery. Long-term follow-up from the Swedish Obese Subjects study reported in *JAMA* showed that although fewer medications were used by bariatric patients compared with controls, the bariatric patients used substantially more hospital resources.[1] A formal cost-effectiveness study using very high-quality data from the US Department of Veterans Affairs did not show a cost benefit for Roux-en-Y gastric bypass.[2] In this issue of *JAMA Surgery*,[3] an analysis of claims paid by BlueCross BlueShield for bariatric surgery patients for as long as 6 postoperative years failed to demonstrate a cost benefit for weight loss surgery. Coupled with findings that bariatric surgery confers little to no long-term survival benefit,[4] these observations show that bariatric surgery does not provide an overall societal benefit. In other words, the indications for bariatric surgery should be viewed in terms of individual patient benefit without anticipating that there will be cost savings to a health care system by offering this treatment.

Bariatric surgery clearly benefits some patients. Current data suggest that weight loss operations should be offered to highly selected patients. Patients considered for bariatric surgery should have a complication of obesity that is known to dramatically improve with weight loss surgery. Examples include diabetes and osteoarthritis. These operations should not be done for body mass index as an exclusive indication.[5] Surgery should be offered only to patients with demonstrated compliance to medical and dietary treatment. Operations with questionable long-term effectiveness such as laparoscopic banding procedures should be avoided.

Bariatric surgery has dramatic short-term results, but on a population level its outcomes are far less impressive. In this era of tight finances and inevitable rationing of health care resources, bariatric surgery should be viewed as an expensive resource that can help some patients. Those patients should be carefully vetted and the operations offered only if there is an overwhelming probability of long-term success.

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