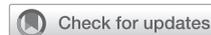


# Association of Bariatric Surgery and National Medication Use



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- BACKGROUND:** Bariatric surgical procedures are an effective and enduring treatment for severe obesity. In addition to improvements in health status, bariatric operations have been noted to potentially decrease postoperative healthcare costs, particularly medication use.
- STUDY DESIGN:** We performed a longitudinal analysis of 2007-2012 claims data comparing a bariatric surgical cohort with a propensity-matched nonsurgical control group during a 5-year time period. Truven Health Analytics MarketScan Commercial Claims and Encounters Database, with a total enrollment of 56 million covered lives from all insurers and representing all 50 states, was used. An initial sample of 384,343 obese patients was identified, with a total of 5,978 matched 1:1 pairs of obese bariatric surgical patients and nonsurgical control patients designated after matching and propensity score matching procedure. Two thousand seven hundred of those matched pairs had at least 4 years of follow-up after index date.
- RESULTS:** The matched cohorts included 2,700 patients (77.2% female, mean age 47.1 years). During the 4-year follow-up period, bariatric surgical patients had 22.6% lower pharmacy costs compared with nonsurgical control patients ( $p < 0.001$ ). Mean total pharmacy costs showed a sustained decrease in the surgical group compared with the matched control group (\$8,411 vs \$9,900;  $p < 0.001$ ). Medication use in the surgical group declined significantly from 1 year preoperative to 4 years postoperative in contrast to the control group. In the 4-year postoperative period, the numbers of antidiabetic, antihypertensive, and cardiac prescriptions in the surgical patients were reduced by 73.7%, 48.3%, and 48.9%, respectively, compared with the control patients.
- CONCLUSIONS:** Total pharmacy use and costs showed a significant and sustained reduction during a 4-year follow-up period among patients undergoing gastric bypass or band operations in comparison with a propensity-matched control group. (J Am Coll Surg 2019;228:171–179. © 2018 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Obesity imposes a substantial health and economic toll, affecting more than one-third of adults and 17% of children and adolescents in the US.<sup>1,2</sup> According to CDC

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estimates, the prevalence of obesity is highest among adults aged between 40 and 59 years (39.5%) compared with those aged between 20 and 39 years (30.3%) and the elderly population (older than 65 years) (35.4%).<sup>3</sup> Approximately 4.8% of the obese population is staged as severe obesity (defined as BMI  $\geq 40$  kg/m<sup>2</sup>). The surge in the prevalence of obesity has caused a corresponding increased risk of obesity-related comorbidities, with more than two-thirds of severely obese (BMI  $> 40$  kg/m<sup>2</sup>) patients having at least 1 comorbid condition, such as type 2 diabetes, hypertension, sleep apnea, dyslipidemia, coronary artery disease, stroke, and osteoarthritis.<sup>3</sup> Correspondingly, obese patients incur substantial healthcare costs, particularly medication costs.<sup>4</sup>

The American Medical Association's declaration that obesity is a disease has crystallized interest not only in preventing obesity, but also in treating obesity.<sup>5</sup> Although

obesity therapies, such as medications and integrated intensive counseling, are emerging and promising, long-term data on their effectiveness for both weight reduction and resolution of comorbidities are still anticipated.<sup>6</sup> Bariatric surgical procedures have served as “first responder” to this treatment need for obesity. Bariatric operations have been repeatedly demonstrated to be both safe and effective in this comorbid population.<sup>7</sup> Bariatric operations are effective for treating severely obese patients and have been proven to substantially lower weight, reduce comorbidities, and even enhance survival.<sup>8</sup> Several randomized controlled studies have compared treatment outcomes in severely obese patients treated with bariatric operations with those treated nonsurgically and have provided evidence supporting the positive health benefits of bariatric operations.<sup>9,10</sup>

Although bariatric surgical procedures impart multiple clinical benefits, it is not known whether these positive clinical outcomes translate to positive healthcare economic outcomes. Some studies have demonstrated both clinical and economic benefits of bariatric operations, but from single institutions and/or with limited follow-up data.<sup>11-14</sup> Larger, longer-term clinical studies, such as the Swedish Obese Subjects Trial, compared the healthcare use of patients who had undergone bariatric operations with those treated conventionally.<sup>15</sup> Surgically treated patients had higher healthcare use during the first 6-year period and lower overall drug costs from years 7 through 20 after bariatric operation. Lam and colleagues<sup>12</sup> reported a concomitant reduction in the average number of prescription medications from 3.5/patient preoperatively to 1.1/patient at 1 year, equating to a monthly cost savings of US\$195.80/patient. Health economic studies have demonstrated either overall healthcare costs reduction or medication cost reduction.<sup>16</sup> Weiner and colleagues<sup>13</sup> study reported no short- or long-term reductions in overall healthcare costs associated with bariatric operations. However, the study is limited by its reliance on a single-payor and the lack of long-term follow-up provided, and its data predated both the modern bariatric surgery accreditation initiative and the laparoscopic approach, which have each demonstrated lower complications rates and cost.<sup>17,18</sup>

Given that obesity-related chronic diseases, such as diabetes and hypertension, are primarily treated with medications, this study's aim was to demonstrate the differences in pharmacy cost and use for a cohort of obese patients who underwent bariatric operations compared with matched, obese patients treated nonsurgically in a multiple payor and national setting. We hypothesized that patients in the surgical cohort would have lower pharmacy-related health expenditures and use in the years

after bariatric operation than those in the nonsurgical control cohort.

## METHODS

### Data source

This retrospective longitudinal cohort study used administrative medical and pharmacy claims data from the Truven Health Analytics MarketScan Commercial Claims and Encounters Database for the period January 1, 2007 through December 31, 2012,<sup>19</sup> as these data were available for review. This database includes complete longitudinal records of inpatient services, outpatient services, long-term care, and prescription drug claims covered under a variety of fee for service, point of service, and capitated reimbursement schemes. All study data were de-identified and complied with all aspects of the Health Insurance Portability and Accountability Act of 1996 and were therefore exempted from IRB approval. Truven Health Analytics MarketScan Commercial Claims and Encounters Database incorporates multiple states and insurers with a total enrollment of 56 million covered lives representing all 50 states.

### Patient selection

Men and women who were identified as having inpatient or outpatient diagnoses of morbid obesity with comorbidity (ICD-9-CM code 278.01), BMI  $\geq 40$  kg/m<sup>2</sup> (ICD-9-CM code V85.4), or BMI 35 to 40 kg/m<sup>2</sup> with comorbidity (ICD-9-CM codes V85.35-V85.39) between January 1, 2007 and December 31, 2008, and who were 18 years of age or older were eligible for inclusion. Patients in the surgical cohort were required to have at least 1 inpatient or nondiagnostic outpatient claim for laparoscopic gastric band or laparoscopic Roux en-Y gastric bypass procedure (ICD-9-CM procedure code 44.38, 44.95) in 2008. Sleeve gastrectomy was not a commonly performed procedure in 2008 and so was not included in the analysis. The time period was chosen on the basis of available data. To ensure a homogeneous surgical cohort, only patients with laparoscopic procedures were chosen. The date of the first bariatric surgical procedure in 2008 was assigned as the index date. Patients were also required to have continuous enrollment with both medical and pharmacy benefits for 12 months pre- and 4 years post-index, no claims for any type of bariatric surgical procedure from January 1, 2007 until the index date, and no evidence of inflammatory bowel disease (ICD-9-CM codes 555.xx to 556.xx), familial adenomatous polyposis (ICD-9-CM code 211.xx), noninfectious colitis (ICD-9-CM codes 557.xx to 558.xx), or malignant neoplasm of digestive

organs or peritoneum (ICD-9-CM codes 150.xx to 159.xx) in 2007 and 2008. Patients in the nonsurgical cohort were subject to the same eligibility criteria as the surgical cohort, except that they had not undergone any bariatric surgical procedures during the study period, to allow for comparison between the 2 groups.

A 1:1 direct match on the 3 direct matching variables of sex, obesity category (BMI  $\geq 40$  kg/m<sup>2</sup> or BMI 35 to 40 kg/m<sup>2</sup> with comorbidity), and length of follow-up was used to select initial control patients similar to bariatric surgical patients. Within each stratum of the 3 direct matching variables, a logistic regression model was used to generate a propensity score that predicted the probability that a patient had bariatric operation based on the following characteristics: age, baseline diabetes diagnosis, baseline total costs, baseline Charlson Comorbidity Index, and geographic region. Patients having operations were matched 1:1 with the pool of control patients by the propensity score using a nearest neighbor matching technique.<sup>20,21</sup> Standardized differences in matching factors between the surgical and nonsurgical cohorts pre- and postmatching were calculated to examine the quality of the match, with standardized differences  $< 10$  indicative of an acceptable match.<sup>22</sup>

### Outcomes measures

Patient demographic variables, age, sex, insurance plan type, geographic location (US Census region), and primary payer were measured. Clinical characteristics measured during the 12-month pre-index period were Deyo-Charlson Comorbidity Index (an indicator of overall burden of illness) and prevalence of prespecified comorbid conditions (ie type 2 diabetes, sleep apnea, hypertension, GERD, cardiovascular disease, and hyperlipidemia).<sup>23</sup> Although individual comorbidity severity was not measured, overall burden of comorbidity was captured by the Charlson Comorbidity Index. Continuous positive airway pressure data were not captured in these data.

Total pharmacy expenditures evaluated during the 1-year baseline period before operation date and 4-year follow-up periods included antidiabetic prescription, antihypertensive, and other cardiac prescription costs. All expenditures were adjusted to 2013 constant dollars using the Medical Care component of the Bureau of Labor Statistics Consumer Price Index (<http://www.bls.gov/cpi/>). Other cost data, including hospitalizations and operations, were not included in this analysis.

### Statistical analysis

All study variables, including demographic characteristics, clinical factors, healthcare use, and costs for each study

cohort, were analyzed descriptively. Categorical variables were compared between cohorts using chi-square test and, for continuous variables, the 2-sample Student's *t*-test was used. Data are presented as mean (SD) unless otherwise stated, and for all tests,  $p < 0.05$  was considered statistically significant.

Multivariable adjustment was conducted on the propensity score-matched sample to examine the marginal effect of bariatric operations on 4-year pharmacy costs. Generalized linear models with a gamma distribution and log link were used to adjust for any remaining imbalances from matching and to estimate the effects of bariatric operations on the 4-year direct costs of total pharmacy expenditures. Poisson quasi-likelihood regressions were used to estimate the effect of bariatric operations on the 4-year count of prescriptions. Pharmacy use outcomes were annual total count and cost of prescriptions, total count and cost of antidiabetic prescriptions, total count and cost of antihypertensive prescriptions, and total count and cost of cardiovascular prescriptions. The primary independent variable of interest was an indicator for operation. The control variables included age group, sex, insurance type, region, Deyo Charlson Comorbidity Index score in pre-period, pre-index diagnosis of hypertension, hyperlipidemia, GERD diagnosis, pre-index period sleep apnea, and pre-index period cardiovascular disease, and count of prescriptions in pre-period. Patients not undergoing operations served as the reference group.

## RESULTS

### Sample size

Of an initial sample of 384,343 identified obese patients, a total of 5,978 matched pairs of obese bariatric surgical patients and control patients without bariatric operations were identified after the direct match and propensity score-matching procedure, and 2,700 of those matched pairs had at least 4 years of follow-up after index date. The matching algorithm are noted in [Table 1](#).

### Demographic and clinical characteristics

After propensity score matching, obese patients with and without bariatric surgical procedures had similar demographic and clinical characteristics, except that surgical patients had a significantly higher proportion of patients with GERD and sleep apnea in the pre-index period ([Table 2](#)). Mean age among surgical patients and control patients was 47.1 years, the percent female in this sample was 77%, and 42% to 54% had a comprehensive or preferred provider insurance plan type.

**Table 1.** Matching Algorithm

Characteristic	Surgical patients, n	Nonsurgical control patients, n
Patients with bariatric operation in 2008	19,345	—
Patients without any bariatric operation in study period (2007 to 2012)	—	233,045
Age 18 y on the index date	7,253	86,411
No evidence of inflammatory bowel disease, familial adenomatous polyposis, noninfectious colitis, or malignant neoplasm of digestive organs or peritoneum in pre-index period	6,974	79,020
Limited to patients with laparoscopic band or laparoscopic Roux-en-Y procedures	6,635	—
1-y pre-index and 4-y post-index continuous enrollment	2,700	25,009
Final sample (after propensity score matching)	2,700	2,700

Patients with a diagnosis of obesity in 2007 and 2008, n = 384,343.

### Pharmacy costs and use

During the 4-year post-index period, surgical patients had significantly lower mean total pharmacy costs (\$8,411 vs \$9,900;  $p < 0.001$ ) compared with control patients without operations (Fig. 1). Differences in 4-year pharmacy costs were attributable to fewer annual antidiabetic prescriptions (3.2 vs 9.9;  $p < 0.001$ ), cardiovascular prescriptions (4.9 vs 7.9;  $p < 0.001$ ), and antihypertensive prescriptions (11.2 vs 19.9;  $p < 0.001$ ), which resulted in reduced expenditure on antidiabetic drugs (\$561 vs \$1,669;  $p < 0.001$ ), cardiovascular drugs (\$729 vs \$1,089;  $p < 0.001$ ), and antihypertensive drugs (\$492 vs \$916;  $p < 0.001$ ) among bariatric surgical patients compared with control patients (Figs. 2 and 3). All cost data were from Poisson regression models. The proportion of bariatric surgical patients receiving antidiabetic medications decreased from 34% to 21% from the baseline period to the 4-year post-index period, and the proportion among control patients increased from 30% to 38% in the same time period. In addition, the proportion of bariatric surgical patients receiving antihypertensive medications decreased from 66% to 59% from the baseline period to the 4-year post-index period, and the proportion among control patients increased from 59% to 70% in the same time period. Similarly, the proportion of patients receiving cardiovascular medications decreased among bariatric surgical patients (42% to 40%), in contrast to an increase in the percentage of control patients receiving these medications (34% to 46%) (Fig. 4).

After adjusting for any remaining differences in baseline patient characteristics, bariatric surgical patients compared with control patients had a 22.6% reduction in 4-year total prescription costs (cost ratio 0.774; 95% CI 0.728 to 0.821) and significantly fewer antidiabetic prescriptions (incidence rate ratio 0.263; 95% CI 0.256 to 0.270), antihypertensive prescriptions (incidence rate ratio 0.517; 95% CI 0.510 to 0.525), and cardiovascular prescriptions (incidence rate ratio 0.511; 95% CI 0.500 to 0.523)

compared with control patients (Table 3). Gastroesophageal reflux disease was not included as a prescription end point, given that its medical treatment can include multiple over-the-counter medications, including proton-pump inhibitors, which are not captured in this database.

### DISCUSSION

The results of this study demonstrate that total pharmacy expenditure and use measured during a 4-year period were significantly lower for the severely obese cohort who underwent bariatric operations compared with the matched patients treated nonsurgically. Many studies have reported substantial decreases in medication use and associated expenditure after bariatric operation.<sup>11-14</sup> However, these studies provided data from patients who were followed for relatively shorter time spans post operation. These data are drawn from a unique database, which included all 50 states, longitudinal assessment, and all payors.

Bariatric surgical procedures have been demonstrated to offer several clinical and economic benefits in the morbidly obese patients, including substantial weight loss coupled with remission of obesity-associated complications.<sup>24-28</sup> Studies have also reported that bariatric operations have the potential to reduce the high pharmaceutical costs and use associated with obesity.<sup>29-32</sup> In the current study, the total pharmacy costs in the first year after operation did not differ significantly between surgically and nonsurgically treated cohorts. However, significant cost differences in total pharmacy costs were observed 4 years after operation. Differences in the total pharmacy costs and use observed during the 4-year follow-up period in the current study were due primarily to lower costs of antidiabetic, cardiovascular, and antihypertensive prescriptions among surgical patients compared with matched control patients. In addition, bariatric surgical patients were found to have a 22.6% reduction in 4-year total prescription costs compared

**Table 2.** Baseline Characteristics of Bariatric Surgical Patients and Matched Nonsurgical Control Patients

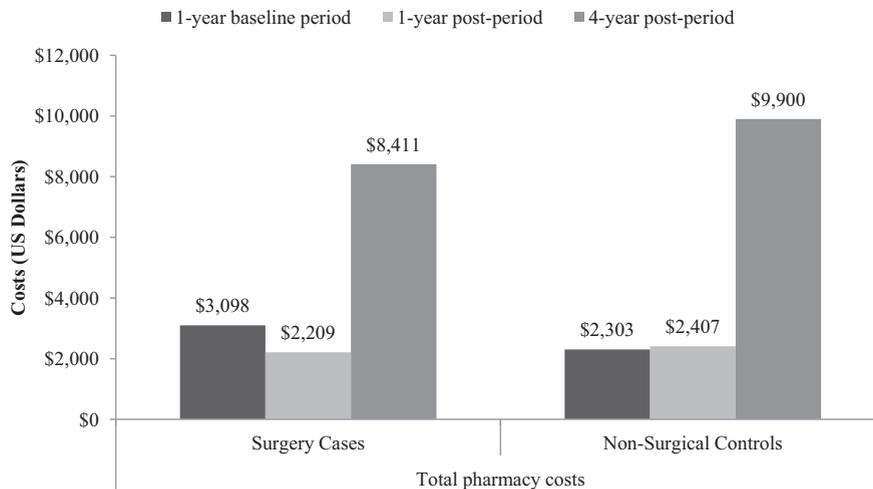
Characteristic	All surgical patients (n = 2,700)	Laparoscopic Roux en-Y patients (n = 1,833)	Laparoscopic band patients (n = 867)	Nonsurgical control patients (n = 2,700)
Age, y, mean (SD)	47.1 (9.6)	47.0 (9.5)	47.2 (9.8)	47.1 (10.0)
Age group, n (%) <sup>*</sup>				
18 to 29 y	96 (3.6)	67 (3.7)	29 (3.3)	137 (5.1)
30 to 44 y	926 (34.3)	630 (34.4)	296 (34.1)	885 (32.8)
45 to 64 y	1,678 (62.1)	1,136 (62.0)	542 (62.5)	1,678 (62.1)
Sex, n (%)				
Male	616 (22.8)	415 (22.6)	201 (23.2)	616 (22.8)
Female	2,084 (77.2)	1,418 (77.4)	666 (76.8)	2,084 (77.2)
Geographic region, n (%)				
Northeast	289 (10.7)	187 (10.2)	102 (11.8)	292 (10.8)
North central	749 (27.7)	487 (26.6)	262 (30.2)	778 (28.8)
South	853 (31.6)	552 (30.1)	301 (34.7)	828 (30.7)
West	793 (29.4)	593 (32.4)	200 (23.1)	795 (29.4)
Unknown	16 (0.6)	14 (0.8)	2 (0.2)	7 (0.3)
Health plan type, n (%)				
Fee for service	111 (4.1)	79 (4.3)	32 (3.7)	137 (5.1)
Exclusive service provider/preferred provider organization	1,288 (47.7)	824 (45.0)	464 (53.5)	1,121 (41.5)
POS/POS with capitation	445 (16.5)	300 (16.4)	145 (16.7)	360 (13.3)
HMO	769 (28.5)	572 (31.2)	197 (22.7)	985 (36.5)
High-deductible health plan/consumer-driven health plan	67 (2.5)	44 (2.4)	23 (2.7)	78 (2.9)
Other	20 (0.7)	14 (0.8)	6 (0.7)	19 (0.7)
Population density, n (%)				
Urban	2,281 (84.5)	1,544 (84.2)	737 (85.0)	2,269 (84.0)
Rural	417 (15.4)	287 (15.7)	130 (15.0)	430 (15.9)
Unknown	2 (0.1)	2 (0.1)	0 (0.0)	1 (0.0)
Deyo Charlson Comorbidity Index, mean (SD)	0.7 (1.0)	0.8 (1.1)	0.7 (1.0)	0.7 (1.2)
Comorbid conditions during pre-index, n (%)				
Type 2 diabetes	945 (35.0)	659 (36.0)	286 (33.0)	930 (34.4)
Sleep apnea <sup>*</sup>	1,068 (39.6)	720 (39.3)	348 (40.1)	506 (18.7)
Hypertension <sup>*</sup>	1,485 (55.0)	1,005 (54.8)	480 (55.4)	1,281 (47.4)
GERD <sup>*</sup>	667 (24.7)	452 (24.7)	215 (24.8)	301 (11.1)
Cardiovascular disease <sup>*</sup>	1,779 (65.9)	1,203 (65.6)	576 (66.4)	1,531 (56.7)
Hyperlipidemia <sup>*</sup>	777 (28.8)	528 (28.8)	249 (28.7)	647 (24.0)

<sup>\*</sup>Comparison of all surgical patients with nonsurgical control patients; statistically significant at  $p < 0.05$ .

POS, point of service.

with the matched control patients. This study endorses the results of sustained reduction in overall pharmacy costs after bariatric operations reported by the majority of the previous studies.<sup>24-32</sup> Differences between our results and those of previous studies might be due to the relatively larger sample size analyzed, coupled with longer follow-up. It should be noted that surgical prescription costs did increase in later years, which could potentially be attributed to weight gain.

This study also analyzed the rate of prescription drug use among patients with and without operation. In a historical cohort study of 6,235 obese patients who underwent bariatric operations, use of antidiabetic, antihypertensive, and antilipidemic medications declined by 76%, 51%, and 59%, respectively, during a 12-month period post operation.<sup>28</sup> During 4-year follow-up, the percentage of patients receiving antidiabetic, cardiovascular, and antihypertensive medications decreased among bariatric



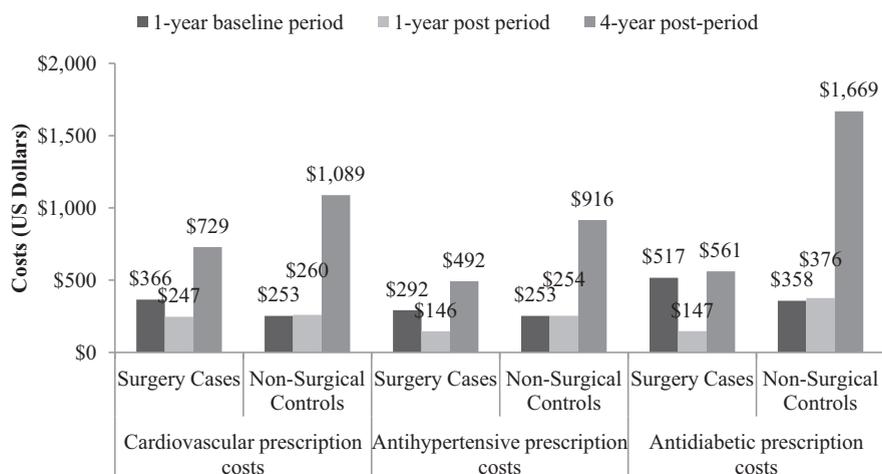
**Figure 1.** Total pharmacy costs in 1-year baseline period, 1- and 4-year post-index periods.

surgical patients, and the proportion of patients increased steadily over time in the nonsurgically treated cohort.

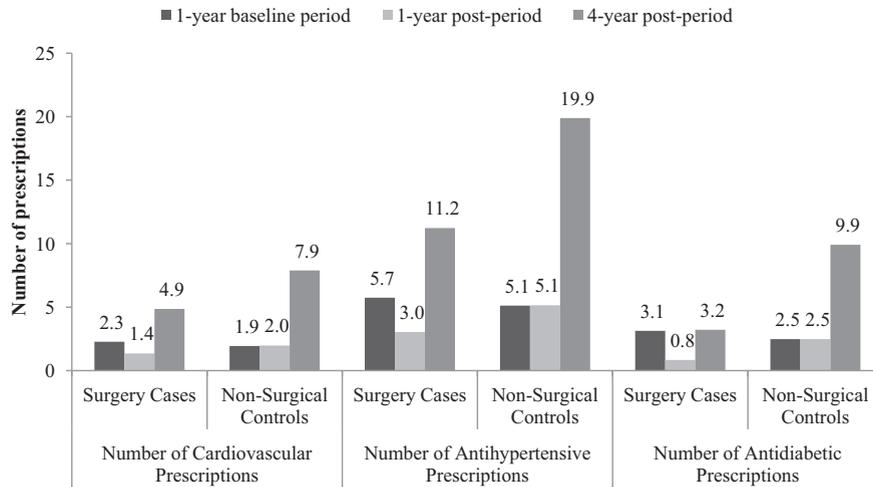
Data from several studies have demonstrated the effectiveness of bariatric operations in reducing obesity-related comorbidities, such as type 2 diabetes, hypertension, dyslipidemia.<sup>14,33</sup> In a meta-analysis, bariatric operations resulted in effective weight loss in morbidly obese patients, coupled with remission of diabetes, hyperlipidemia, hypertension, and obstructive sleep apnea.<sup>29</sup> Improvement or complete resolution of obesity comorbidities has been shown to considerably lower the use of medications for obesity-related complications and prescription drug cost reduction.<sup>24-32</sup> Although we did not evaluate the rate of comorbidities before and after bariatric operations, the decreased rate of prescription drug use during a 4-year follow-up among patients who

underwent operations compared with those in the nonsurgical cohort are likely due to improvement in comorbidities post operation.

Several limitations inherent to administrative claims data apply to our study as well. This analysis was based on a population covered by commercial insurance. Consequently, results of this analysis might not be generalizable to obese patients with other insurance or populations without health insurance coverage. There is a scope for misclassification of obesity, covariates, or study outcomes, as patients were identified through administrative claims data as opposed to medical records. Unfortunately, obesity is often not coded appropriately or at all, which could limit our ability to match patients.<sup>34</sup> Another limitation is the lack of laparoscopic sleeve gastrectomies represented in this study. The study time period predated



**Figure 2.** Prescription drug costs in 1-year baseline period and 1- and 4-year post-index periods.

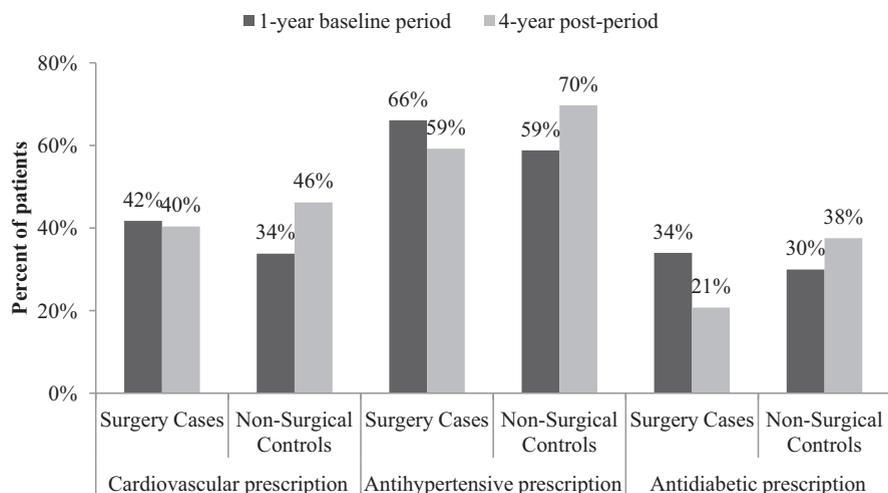


**Figure 3.** Prescription drug use in 1-year baseline period and 1- and 4-year post-index period.

dedicated coding for laparoscopic sleeve gastrectomy. Like all of the administrative healthcare claims databases, the MarketScan Commercial database relies on administrative claims data, therefore, the data might be subject to misclassification resulting from diagnostic coding errors. Despite balance in baseline characteristics between the bariatric surgical and control cohorts, possible bias due to imbalance in unidentified covariates cannot be ruled out.

An additional limitation to this study is that only drug costs were examined. Additional cost data not captured are drug copays or supplemental insurance for drug coverage. Additional study is needed to also determine overall healthcare costs, including hospitalizations,

readmissions, and procedures. However, interpretation of inpatient costs increasing after bariatric operation must be approached with caution. Many of the inpatient costs shown in the study by Weiner and colleagues,<sup>13</sup> for example, were likely care deferred for the obese, which were not offered treatment until weight loss was achieved. For example, it is increasingly apparent that obesity increases orthopaedic complications, among many other interventions, potentially leading to limitation of therapy for this population.<sup>35</sup> This resultant disparity of care for the obese is not limited to surgical procedures, but includes preventive care as well.<sup>36</sup> Although some initial studies did not demonstrate reductions in short-term costs, a subsequent long-term study did demonstrate



**Figure 4.** Patients with prescription drug use in 1-year baseline period and 4-year post-index period.

**Table 3.** Multivariable Results of Total Pharmacy Expenditures in 4-Year Post-Index Period, Poisson Quasi-Likelihood Regressions

Outcomes	Ratio	95% Confidence limits	p Value
Total prescription costs, cost ratio	0.774	0.728, 0.821	<0.0001
Antidiabetic prescriptions, IRR	0.2627	0.2560, 0.2696	<0.0001
Antihypertensive prescriptions, IRR	0.5172	0.5096, 0.5250	<0.0001
Cardiac prescriptions (excluding antihypertensives), IRR	0.5111	0.4995, 0.5230	<0.0001

IRR, incidence rate ratio.

long-term improvement in mortality after bariatric operation.<sup>37,38</sup>

This study was unique, as it evaluated a large data set from a large administrative database along with providing 4-year data on pharmacy-related cost and use among morbidly obese patients with and without bariatric operations.

Although this study has demonstrated direct cost reduction by bariatric operation within the insured population, considerations for both perspective and time horizon must be given. In examining a societal problem like obesity, a societal perspective should be maintained, given the short-term outlook for payors when examining benefits for enrollees who might switch plans frequently. Using this premise of societal perspective, numerous publications support the cost-benefit of bariatric operations.<sup>14,33</sup>

Although we did not have weight or comorbidity data, the control group that did not undergo bariatric operations might have worsening health status over time, as seen by the proxy of increased drug costs. In addition, it is entirely possible that certain medications might be weight-promoting; drug adherence in the obese population is limited, which can severely undermine treatment of comorbidity and these medications can result in emergency department visits.<sup>39,40</sup>

## CONCLUSIONS

In this study, the surgical cohort did not have a similar progression of disease as seen in the control group. The control group, in a 4-year time period, saw cardiovascular, hypertensive, and diabetes annual prescriptions rise 4-fold, and the surgical group saw significant declines in prescriptions for these chronic diseases. In summary, this study found that, after direct matching and multivariable adjustment, patients who have undergone bariatric surgical procedures have significantly lower 4-year pharmacy-related costs and use compared with nonsurgically treated obese patients. Additional studies are warranted to investigate whether reductions in pharmacy use result in long-term resolution of obesity-related comorbid conditions and ultimately impact health-related quality and quantity of life.

## Author contributions

Study conception and design: Morton

Acquisition of data: Morton, Malangone-Monaco

Analysis and interpretation of data: Morton, Ponce, Malangone-Monaco, Nguyen

Drafting of manuscript: Morton, Malangone-Monaco

Critical revision: Morton, Ponce, Malangone-Monaco, Nguyen

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