HHS Public Access

Author manuscript

Ann Surg. Author manuscript; available in PMC 2023 July 01.

Published in final edited form as:

Ann Surg. 2022 July 01; 276(1): 133–139. doi:10.1097/SLA.0000000000004526.

Bariatric Surgery in Medicare Patients: Examining Safety and Healthcare Utilization in the Disabled and Elderly

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Abstract

Objective: To compare safety and healthcare utilization after sleeve gastrectomy versus Roux-en-Y gastric bypass in a national Medicare cohort.

Summary Background Data: Though bariatric surgery is increasing among Medicare beneficiaries, no long-term, national studies examining comparative effectiveness between procedures exist. Bariatric outcomes are needed for shared decision-making and coverage policy concerns identified by the CMS Medicare Evidence Development and Coverage Advisory Committee.

Methods: Retrospective instrumental variable analysis of Medicare claims (2012-2017) for 30,105 bariatric surgery patients entitled due to disability or age. We examined clinical safety outcomes (mortality, complications, and reinterventions), healthcare utilization (ED visits, rehospitalizations, and expenditures), and heterogeneity of treatment effect. We compared all outcomes between sleeve and bypass for each entitlement group at 30 days, 1 year, and 3 years.

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Conflicts of Interest: Dr. Dimick is a cofounder of ArborMetrix, Inc, a company that makes software for profiling hospital quality and efficiency. Dr. Telem receives consulting fees from Medtronic. Dr. Chhabra receives payments from Blue Cross Blue Shield of Massachusetts, Inc All reported conflicts had no role in the work herein.

Meeting Presentation: An earlier version of this analysis was presented at the Academic Surgical Congress (February 5, 2020, Orlando, FL).

Results: Among the disabled (n=21,595), sleeve was associated with lower 3-year mortality (2.1% vs 3.2%, ARR 95%CI: −2.2% to −0.03%), complications (22.2% vs 27.7%, ARR 95%CI: −8.5% to −2.6%), reinterventions (20.1% vs 27.7%, ARR 95%CI: −10.7% to −4.6%), ED utilization (71.6% vs 77.1%, ARR 95%CI: −8.5% to −2.4%), and rehospitalizations (47.4% vs 52.3%, ARR 95%CI: −8.0% to −1.7%). Cumulative expenditures were $46,277 after sleeve and $48,211 after bypass (*P*=.22). Among the elderly (n=8,510), sleeve was associated with lower 3-year complications (20.1% vs 24.7%, ARR 95%CI: −7.6% to −1.7%), reinterventions (14.0% vs 21.9%, ARR 95%CI: −10.7% to −5.2%), ED utilization (51.7% vs 57.2%, ARR 95%CI: −9.1% to −1.9%), and rehospitalizations (41.8% vs 45.8%, ARR 95%CI: −7.5% to −0.5%). Expenditures were $38,632 after sleeve and $39,270 after bypass (*P*=.60). Procedure treatment effect significantly differed by entitlement for mortality, revision, and paraesophageal hernia repair.

Conclusion: Bariatric surgery is safe, and healthcare utilization benefits of sleeve over bypass are preserved across both Medicare elderly and disabled subpopulations.

Mini-Abstract

This study compared 30-day, 1-year, and 3-year post-operative safety and healthcare utilization outcomes between laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass in Medicare disabled and elderly beneficiaries. To account for unmeasured confounding, we used an instrumental variable method. We found at 3 years, sleeve was safer and led to less healthcare utilization than bypass for patients regardless of entitlement reason.

Introduction:

Bariatric surgery is a highly safe and effective treatment for obesity and metabolic syndrome. Despite this, policymakers for several years have considered withdrawing Medicare coverage of bariatric surgery given the lack of post-operative data for Medicare-insured patients.[1] Medicare patients have a theoretically uncertain risk-benefit profile for bariatric surgery since they are often older and more medically complex than commercially-insured counterparts.[2, 3] Thus, they may be at higher risk for complications and have fewer years to benefit from surgery. Given this uncertainty, the Medicare Evidence Development and Coverage Advisory Committee[1] and Agency for Healthcare Research and Quality[4] identified a critical need to evaluate the safety and outcomes for bariatric surgery in Medicare beneficiaries.

Currently, studies of Medicare patients who undergo bariatric surgery are limited in important ways.[2-5] Many studies are based on data prior to the modern era of laparoscopic sleeve gastrectomy. Studies tend to be single center and thus are not generalizable nationally. In addition to issues with study population, selection bias in surgical procedure limits causal inference to compare outcomes for different procedures.[6] Furthermore, comparative healthcare resource use and spending between sleeve gastrectomy and gastric bypass have not been previously studied in Medicare patients. Lastly, there may be important differences between patients entitled due to disability and those entitled due to age.

We thus examine national Medicare claims to understand the comparative effectiveness of the two most common bariatric surgery procedures – laparoscopic sleeve gastrectomy versus Roux-en-Y gastric bypass. We separately analyze the two major Medicare entitlement groups: disability and age 65 years or greater. To account for potential procedure selection bias, we use an instrumental variable method to understand the specific risks regarding which procedure is safer and associated with less healthcare utilization. We then examine whether there is heterogeneity of treatment effect when accounting for entitlement group.

Methods:

Data Source and Study Population

We used 100% fee-for-service Medicare claims (Part A, Part B, outpatient, and home health agency) for patients who underwent laparoscopic sleeve gastrectomy or laparoscopic Roux-en-Y gastric bypass from January 1, 2012 to December 31, 2014 with continuous 3-month pre-surgical and 3-year post-surgical enrollment. We used data starting from January 1, 2011 to develop our instrumental variable (see Statistical Analysis) and tracked outcomes until December 31, 2017. We identified patients for cohort creation using CPT codes 43775, 43644, 43645, 43844, 43846+43659, or 43847+43659; matching *International Classification of Diseases 9th and 10th* diagnosis codes for morbid obesity; and a diagnosis related group code for bariatric surgery (619, 620, 621). For analysis, we stratified Medicare patients by initial reason for Medicare entitlement – disability or age 65 years or greater (elderly) – given heterogeneity between these demographics.

Patients were excluded if entitled to Medicare due to ESRD (2.1% of bariatric surgery patients) as they likely have different baseline surgical risk. Patients were also excluded if they had a diagnosis code reflecting gastric or small bowel cancer associated with surgery to ensure our cohort only included patients undergoing bariatric surgery.

Outcomes

Primary Outcome—Our primary outcome of interest was clinical safety – cumulative rates of mortality, complications, and reinterventions – at 30 days, 1 year, and 3 years after surgery. Complications most commonly associated with bariatric surgery were identified via ICD-9/10 diagnosis and procedure codes based on previously published work (Supplemental Digital Content, Table 1). These include splenic, hemorrhagic, anastomotic, wound-related, obstruction-related, pulmonary, cardiac, neurologic, genitourinary, thromboembolic, postoperative shock, and unexpected reoperation-related.[7]

Reintervention CPT codes were obtained from review of the literature and CPT coding manual. These codes expand upon a group used in other studies[8] and were reviewed by an investigator not otherwise involved with this study for consistency with the rest of the comparative effectiveness literature in bariatric surgery.[9] This list is available in Supplemental Digital Content, Table 2. Reinterventions were further subcategorized as follows:

1. Revision: Operation modifying the index bariatric procedure. This included conversion to another bariatric procedure (*e.g.* sleeve gastrectomy to gastric bypass), any gastrectomy, or anastomotic revision.
2. Enteral access: Surgical, endoscopic, or interventional enteral access procedure.
3. Vascular Access: Vascular access procedures to reflect the need for parenteral nutrition.
4. Reoperation: Other abdominal operation potentially a sequela of the index bariatric procedure but not affecting bariatric physiology. This included abdominal wall hernia repair, biliary procedure, internal hernia repair, paraesophageal hernia repair, and other abdominal procedure. We excluded operations found within 30 days of the index bariatric operation as there can be up to a 30-day lag time in coding for primary procedures in administrative data. This was done to avoid erroneously considering components of the primary operation as a reintervention in 30-day analysis.
5. Other reintervention: Drainage, aspiration, diagnostic laparoscopy, *etc.*

Secondary Outcomes—Healthcare utilization outcomes included Emergency Department (ED) visits, rehospitalizations, and expenditures. We measured outcomes at 30 days, 1 year, and 3 years after surgery. We identified ED visits using a revenue center code algorithm previously described by the Research Data Assistance Center.[8] We categorized ED visits resulting in admission as rehospitalizations only. For expenditures, we used cumulative Medicare spending following surgery. We performed price standardization to 2017 dollars using previously described methods adjusting for intentional differences in Medicare prices for the same services.[10-13]

Statistical Analysis

Analytic Approach Overview—We examined the effect of surgical procedure on outcomes using an instrumental variable (IV) approach to adjust for confounding from procedure selection. Based on previous literature, patients selected to undergo gastric bypass over sleeve gastrectomy tend to have higher BMI, rates of diabetes mellitus, and GERD.[8, 14, 15] Thus, patients who undergo gastric bypass are often sicker in ways not measurable through administrative data, rendering traditional multivariable regression adjustment inadequate. An IV approach allows us to address unmeasured confounding of selection bias when conducting comparative effectiveness analyses. The IV approach uses external causes of variation as a natural experiment to generate “pseudo-randomization” in procedure selection (sleeve gastrectomy or gastric bypass).[16-18] We used the two-stage residual inclusion IV estimation method, which has been shown to have superior performance for non-linear outcomes.[19, 20]

Instrumental Variable Assumptions—Our instrument was state-level sleeve gastrectomy utilization (relative to gastric bypass) in the prior year. To be valid, an instrument must be both 1) highly associated with selection of treatment and 2) affect outcomes of interest only through treatment choice—not through any other clinical or

contextual factors.[17] Prior year state-level sleeve gastrectomy utilization satisfies these conditions because it is an external source of variation associated with procedure choice without influencing safety and healthcare utilization outcomes directly.[21] External factors of physician preference, local practice patterns, and regional differences in Medicare sleeve gastrectomy coverage determinations[22] drove geographic and temporal variations seen in Supplemental Digital Content, Figure 1. We confirmed this instrument was highly correlated with selection of sleeve gastrectomy with an F-statistic of 148; a typical minimum F-statistic for a valid instrument is 10.[18]

Instrumental Variable Modeling Approach—In our IV-adjusted analyses, we controlled for age, gender, race, operative year, Elixhauser comorbidities, and interactions between procedure and entitlement reason using multivariable logistic or linear regression as appropriate for the outcome of interest. In the first stage, we measured the association between utilization of sleeve gastrectomy and the instrument (prior year state-level sleeve gastrectomy utilization), adjusting for covariates mentioned above. Residuals from the first-stage model which represent unobserved factors influencing procedure selection (actual observed probability of undergoing sleeve gastrectomy minus model-predicted probability) were then included as a covariate in the second-stage model. We used bootstrapping to obtain accurate standard errors.

Heterogeneity of Treatment Effect—When examining two groups in comparative effectiveness research, we can explore interactions of treatment and group. These interactions, known as heterogeneous treatment effects, allow us in a systematic way to evaluate for differences in procedure outcomes by group. We examined whether the difference between procedures varied depending on entitlement group – in two ways: 1) patterns in absolute risk reduction between sleeve gastrectomy and gastric bypass 2) statistical significance of the interaction term between procedure and entitlement group included in the regression. A statistically significant interaction term suggests the difference between sleeve gastrectomy and gastric bypass is influenced by the patient's entitlement reason.

In addition to the IV approach, we used univariate statistical tests as appropriate (chi-squared, t-test, *etc*) to assess for baseline differences in patients who underwent each operation. All statistical tests were two-sided and performed at the 5% significance level. Cohorts were prepared and analyzed in SAS version 9.4 (SAS Institute Inc, Cary, North Carolina). The study was deemed exempt by the University of Michigan Institutional Review Board given the use of de-identified administrative data.

Results:

We identified 30,105 patients who underwent bariatric surgery from 2012-2014 with complete 3-year follow-up. Of these, 21,595 (72%) were disabled and 8,510 (28%) were elderly (Table 1). The average age of disabled patients undergoing bariatric surgery was 51.5 years (SD 10.5) and 68.3 years (SD 2.75) for those entitled due to age ($P<.0001$). Sleeve gastrectomy overtook gastric bypass as the most common bariatric operation in 2013 for both entitlement groups. Within both entitlement groups, diabetes without complications

was significantly more prevalent in patients who underwent gastric bypass than those who underwent sleeve gastrectomy. Patients entitled due to disability had significantly higher rates of congestive heart failure, neurologic disorders, chronic pulmonary disease, diabetes with chronic complications, liver disease, deficiency anemias, psychoses, and depression ($P<.01$). Elderly patients had higher rates of hypertension, diabetes without chronic complications, hypothyroidism, and renal failure ($P<.0001$).

Clinical Safety Outcomes

Instrumental variable analysis showed sleeve gastrectomy had similar or better clinical safety than gastric bypass for most endpoints studied. At 30 days, there were no significant differences between sleeve gastrectomy and gastric bypass for mortality, complications, and reinterventions (Table 2). All unadjusted outcomes are available in Supplemental Digital Content, Table 3.

Within patients with disability, sleeve gastrectomy had statistically significant lower mortality at 3 years (2.1% vs 3.2%, ARR: −1.1%, 95%CI: −2.2% to −0.03%, $P=.043$) (Table 4). Complication rates were significantly lower after sleeve gastrectomy than gastric bypass (22.2% vs 27.7%, ARR: −5.5%, 95%CI: −8.5% to −2.6%, $P<.001$). For overall reintervention rates, there was a large risk reduction seen for sleeve gastrectomy versus gastric bypass (20.1% vs 27.7%, ARR: −7.6%, 95%CI: −10.7% to −4.6%, $P<.001$).

Within elderly patients, sleeve gastrectomy had a survival advantage at 1 year (Table 3) that was no longer seen at 3 years (Table 4). At 3 years, complication rates for elderly patients were significantly lower after sleeve gastrectomy than gastric bypass (20.1% vs 24.7%, ARR: −4.6%, 95%CI: −7.6% to −1.7%, $P=.002$) (Table 4). For overall reintervention rates at 3 years, there was a large risk reduction seen for sleeve gastrectomy versus gastric bypass (14.0% vs 21.9%, ARR: −7.9%, 95%CI: −10.7% to −5.2%, $P<.001$) (Table 4).

Healthcare Utilization Outcomes

For healthcare utilization outcomes in both entitlement groups, sleeve gastrectomy patients were at lower risk for ED visits and rehospitalizations beginning at 3 years (Table 4). In patients with disability, ED utilization rates were 71.6% compared to 77.1% for gastric bypass (ARR: −5.5%, 95%CI: −8.5% to −2.4%, $P=.001$) (Table 4). Patients in both entitlement groups had lower expenditures after sleeve gastrectomy compared to gastric bypass at 30 days with a difference of −$1,582 (95%CI: −$1,932 to −$1,232, $P<.001$) in disabled patients and −$1,444 (95%CI: −$1,955 to −$932, $P<.001$) in elderly patients, but this difference was no longer seen at 1 year (Figure 1).

Disabled patients who underwent bariatric surgery had higher healthcare expenditures compared to elderly patients. Controlling for all covariates including bariatric operation, cumulative expenditures in disabled patients at 3 years on average were $47,184 (95%CI: $45,489 to $48,881) compared to elderly patients at $39,420 (95%CI: $38,081 to $40,759, $P<.001$). Of note, ED utilization was also higher in disabled patients (71%, 95%CI: 70% to 72%) than in elderly patients (65%, 95%CI: 63% to 66%, $P<.001$).

Differences in Treatment Effects across Entitlement Subgroups

We found heterogeneous effects between entitlement groups for mortality, revisions, and paraesophageal hernia repairs at 3 years. Mortality was lower after sleeve gastrectomy than gastric bypass for disabled patients (ARR: −1.1%, *P*=.043) but there was no survival benefit seen within elderly patients (Table 4). There were higher rates of revision and paraesophageal hernia repairs after sleeve gastrectomy in disabled patients, but in elderly patients, there was no difference between procedures. For revisions, the heterogeneous treatment effect for sleeve compared to bypass was indicated by a significant absolute risk reduction in disabled patients (*P*=.021) not seen in elderly patients (*P*=.506) and by a significant interaction term (*P* value of the interaction term of procedure and entitlement group =.001). The difference in treatment effect for paraesophageal hernia repairs was detected by a significant absolute risk reduction seen in the disabled (P=.019) but no significant benefit for sleeve over bypass seen in the elderly (P=.730).

Discussion:

This is the first comprehensive and contemporary study using national Medicare data and rigorous evaluation methods to evaluate the comparative effectiveness of sleeve gastrectomy and gastric bypass within Medicare-entitled patients. This study is consistent with the idea that sleeve gastrectomy is safer and as good as gastric bypass for healthcare resource utilization reduction in both entitlement cohorts. Patients who underwent laparoscopic sleeve gastrectomy had lower 3-year complication, reintervention, ED visit, and rehospitalization rates than those who underwent laparoscopic gastric bypass.

Given the lack of robust data until this point, the fate of bariatric surgery coverage has been somewhat uncertain. The Medicare Evidence Development and Coverage Advisory Committee (MEDCAC) routinely reviews evidence for bariatric surgery to make coverage decisions. Most recently, MEDCAC determined that while coverage for bariatric surgery should continue, more data were needed.[1] In the past, the Centers for Medicare and Medicaid Services did not cover certain bariatric procedures due to lack of studies supporting its benefits over theoretical risks. In fact, Medicare specifically did not allow coverage for laparoscopic sleeve gastrectomy until 2012 when more evidence became available.[23] Past coverage determinations relied on studies with small Medicare numbers or studies of older patients. Thus, our data importantly demonstrate bariatric surgery is safe for Medicare-covered patients, and patients entitled due to age 65 or older had safety and healthcare utilization outcomes better than those entitled due to disability. In fact, all outcomes at 3 years were better among elderly patients than disabled patients.

No other studies to our knowledge have examined bariatric outcomes in the disability subgroup within Medicare. Typically, Medicare patients are thought of as older and sicker than their commercially insured counterparts. However, as our study shows, 72% of Medicare patients who underwent bariatric surgery were entitled due to disability rather than age. Though disabled patients were younger on average than patients entitled due to age, they had higher rates of major comorbidities, notably heart failure, pulmonary disease, diabetes with complications, liver disease, psychoses, and depression. Thus, disabled

patients have higher baseline comorbidity risk and may warrant separate analyses of these two entitlement groups in future analyses of Medicare patients.

Patients entitled to Medicare by disability had different patterns of care utilization compared to those entitled by age. Interestingly, the risk for ED visits after surgery was significantly higher for disabled patients than for elderly patients which may have driven the higher expenditures seen for disabled patients. Higher baseline rates of psychiatric illness in disabled patients may translate to greater mental health needs after surgery which are not being met. A recent study found ED utilization rates for psychiatric diagnoses increased after bariatric surgery.[24] Further studies are needed to understand why ED utilization and expenditures are higher in the disabled, especially given spending related to surgery accounts for approximately half of Medicare spending.[25]

Previous literature has conflicting findings regarding the safety of bariatric surgery among the elderly. Some studies show higher mortality in the elderly compared to younger counterparts, arguing bariatric surgical procedures should be limited to those under age 65.[2, 26, 27] Other studies support the safety of bariatric surgery in the elderly with comparable perioperative mortality compared to the younger population.[28-31] However, a large proportion of bariatric procedures studied in the early 2000s were performed via open technique. More updated studies on safety have focused on laparoscopic gastric bypass and did not include sleeve gastrectomy,[32] the procedure that today makes up the largest proportion of most bariatric surgical practices. Our study using contemporary, national data shows that laparoscopic sleeve gastrectomy and gastric bypass are safe options for elderly Medicare patients.

Examining both the disabled and elderly, the most significant heterogeneous treatment effects were found for revisions and paraesophageal hernia repairs. These were more frequent after sleeve than after bypass in the disabled, but not in the elderly. It is unclear what the cause of this might be and warrants further investigation. Future studies may find more extensive workup for reflux and paraesophageal hernia minimizes the need for reoperation in the disabled Medicare population.

Lastly, while 3-year mortality and hospitalization rates are higher in both Medicare entitlement groups compared to contemporary rates seen in the national PCORnet Bariatric Surgery study cohort (mortality: 0.43% for sleeve gastrectomy, 0.45% for gastric bypass; rehospitalization: 24% for sleeve gastrectomy, 29% for gastric bypass),[33] overall, mortality continues to remain low compared to other surgical procedures. Medicare patients' mortality risk remains lower than that of diabetic patients undergoing laparoscopic cholecystectomy.[34] Smaller studies have identified low mortality and adverse event rates in the Medicare population similar to ours. A study of 3,300 Medicare bariatric surgery patients at a single institution found mortality for all patients to be approximately 3% at 3 years,[35] comparable with our findings.

Our study has several limitations. Administrative data lacks precise clinical characteristics of comorbidities, complications, and reinterventions. Weight, BMI, and factors related to socioeconomic status are also unavailable. However, effect sizes seen in our analysis are

similar to those using clinical registry data.[35] Second, treatment effect estimates from instrumental variable analysis apply only to marginal patients – patients whose procedure selection was affected by the instrument. In other words, IV estimates do not apply to those who could have only gotten sleeve or only gotten bypass. Despite this, IV analysis is one of the only ways to obtain causal estimates from observational data. Additionally, marginal effects are likely the ones most useful to clinicians and patients as they reflect the outcomes in patients for whom both operations are reasonable options. Third, sleeve gastrectomy is a relatively new procedure, and thus only three years of follow-up time were available for analysis. Future studies will assess longer follow-up outcomes as data become available.

Conclusion:

This study addresses the CMS MEDCAC call for evaluation of safety and healthcare use and supports continued bariatric surgery coverage for Medicare patients. In a nationally representative sample, our study is the first to examine the comparative effectiveness in Medicare patients in the modern era of bariatric surgery. Overall, laparoscopic bariatric surgery is safe, and the healthcare utilization benefits of sleeve gastrectomy over gastric bypass are preserved across both the Medicare elderly and disabled subpopulations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

We thank Kristina Lewis, MD, MPH, SM (Division of Public Health Sciences, Wake Forest School of Medicine) for assistance in developing a harmonized list of procedure codes to identify reintervention outcomes in this study.

Sources of Funding: This study was funded by NIDDK grant 5R01DK115408-02. Dr. Chao receives funding from the Veterans Affairs Center for Clinical Management Research, VA Ann Arbor Healthcare System; this work does not represent the views of the United States government nor the Department of Veterans Affairs. Dr. Chhabra receives funding from the University of Michigan Institute for Healthcare Policy and Innovation Clinician Scholars Program and the National Institutes of Health's Division of Loan Repayment. Dr. Telem receives funding from AHRQ K08 HS025778-01A1. Dr. Arterburn receives grants from the National Institutes of Health and nonfinancial support from IFSO Latin America Chapter outside the submitted work. Dr. Dimick receives grant funding from the NIH, AHRQ, and BlueCross BlueShield of Michigan Foundation.

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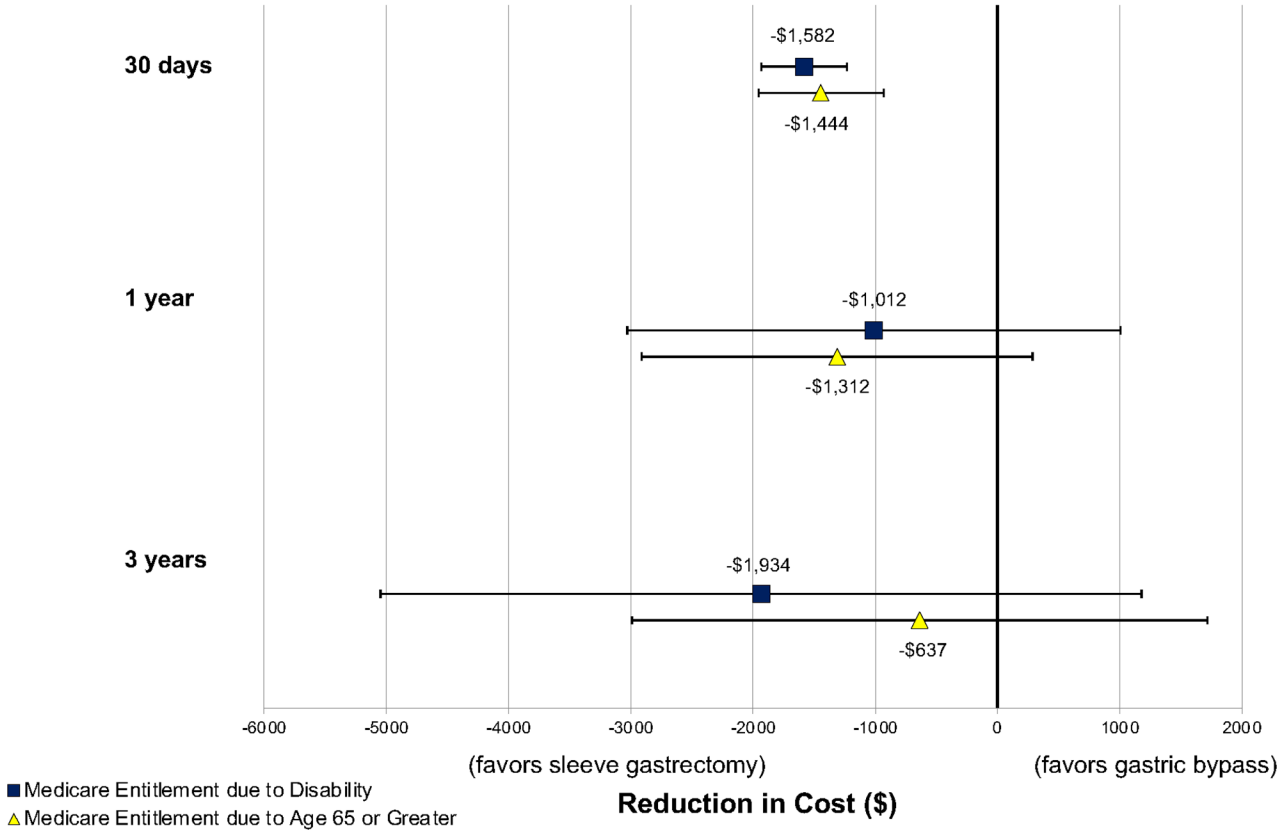

Figure 1.

Differences in cumulative expenditures between sleeve gastrectomy and Roux-en-Y gastric bypass.

Table 1:

Baseline Characteristics of Disability- and Age-Entitled Medicare Patients Who Underwent Bariatric Surgery, 2012-2014

	Disability	**Age 65 years or greater**	***P* value**
	n = 21595 (72%)	n = 8510 (28%)	
Age, mean (SD)	51.46 (10.53)	68.31 (2.75)	<.0001
Female, No. (%)	16352 (75.72)	5807 (68.24)	<.0001
Race/Ethnicity, No. (%)			
Non-Hispanic White	16192 (67.26)	7882 (32.74)	<.0001
Non-Hispanic Black	4010 (91.09)	392 (8.91)	<.0001
Asian American	72 (91.14)	------[a]	<.0001
Hispanic	776 (96.88)	25 (3.12)	<.0001
North American Native	161 (81.73)	36 (18.27)	.002
Other	384 (69.57)	168 (30.43)	.254
Year of operation, No. (%)			
2012	5419 (75.39)	1769 (24.61)	<.0001
2013	7854 (71.88)	3073 (28.12)	<.0001
2014	8322 (69.41)	3668 (30.59)	<.0001
Comorbidities[b], No. (%)			
Congestive heart failure	1397 (6.47)	431 (5.06)	<.0001
Hypertension	16195 (74.99)	7298 (85.76)	<.0001
Other neurological disorders	1300 (6.02)	314 (3.69)	<.0001
Chronic pulmonary disease	6662 (30.85)	1736 (20.4)	<.0001
Diabetes without chronic complications	9807 (45.41)	4472 (52.55)	<.0001
Diabetes with chronic complications	1354 (6.27)	420 (4.94)	<.0001
Hypothyroidism	3722 (17.24)	1752 (20.59)	<.0001
Renal failure	1175 (5.44)	566 (6.65)	<.0001
Liver disease	2961 (13.71)	1056 (12.41)	.003
Fluid and electrolyte disorders	1388 (6.43)	539 (6.33)	.765
Deficiency anemias	1509 (6.99)	447 (5.25)	<.0001
Psychoses	2128 (9.85)	92 (1.08)	<.0001
Depression	7462 (34.55)	1948 (22.89)	<.0001

[a]Cells with number < 11 are suppressed in accordance with the Medicare data use agreement.

[b]Elixhauser comorbidities with a prevalence greater than 5% are listed.

Table 2:

Instrumental Variable Analysis of 30-Day Safety and Healthcare Utilization Outcomes

Cells with number < 11 are suppressed in accordance with the Medicare data use agreement. No reoperations are included in order to account for delays in coding procedures associated with the index bariatric surgery.

	Disability				Age 65 years or greater				$P_{interaction}$ [a]
	Sleeve Gastrectomy, %	RYGB, %	Absolute Risk Reduction, % (95% CI)	*P* value	Sleeve Gastrectomy, %	RYGB, %	Absolute Risk Reduction, % (95% CI)	*P* value	
Mortality	0.2	0.6	−0.5 (−0.9 , 0.00)	.049	0.3	0.5	−0.3 (−0.8 , +0.2)	.307	.160
Complications	9.6	11.8	−2.2 (−4.4 , +0.03)	.054	8.6	10.8	−2.2 (−4.4 , +0.06)	.057	.815
Reinterventions	1.3	2.3	−1.0 (−1.8 , −0.3)	.009	0.7	1.7	−1.0 (−1.8 , −0.1)	.023	.404
Revision	------	0.1	------	.030	------	------	------	.257	.549
Enteral access	0.3	0.6	−0.3 (−0.8 , +0.2)	.277	------	0.4	------	.584	.594
Vascular access	0.7	1.4	−0.7 (−1.4 , −0.003)	.041	0.4	0.9	−0.5 (−1.2 , +0.2)	.135	.861
Other reintervention	0.5	0.6	−0.1 (−0.6 , +0.4)	.786	------	0.5	------	.308	.230
ED visit	21.7	19.5	+2.2 (−1.3 , +5.6)	.219	11.9	12.1	−0.2 (−2.6 , +2.2)	.870	.013
Rehospitalization	7.3	8.3	−1.0 (−2.9 , +0.9)	.299	5.8	5.8	0.0 (−1.5 , +1.4)	.984	.168

Abbreviation: RYGB, Roux-en-Y gastric bypass

[a] $P_{interaction}$ = *P* value of the interaction term between entitlement group and bariatric procedure.

Ann Surg. Author manuscript; available in PMC 2023 July 01.

Table 3:

Instrumental Variable Analysis of 1-Year Safety and Healthcare Utilization Outcomes

Cells with number < 11 are suppressed in accordance with the Medicare data use agreement.

	Disability				Age 65 years or greater				$P_{interaction}$ [a]
	Sleeve Gastrectomy, %	RYGB, %	Absolute Risk Reduction, % (95% CI)	*P* value	Sleeve Gastrectomy, %	RYGB, %	Absolute Risk Reduction, % (95% CI)	*P* value	
Mortality	0.9	2.0	−1.1 (−1.9 , −0.4)	.003	0.8	1.7	−0.8 (−1.6 , −0.1)	.036	.435
Complications	14.8	18.4	−3.6 (−6.3 , −0.9)	.009	12.9	16.7	−3.8 (−6.4 , −1.2)	.004	.531
Reinterventions	10.1	12.9	−2.82 (−5.1 , −0.5)	.015	6.5	9.4	−2.9 (−4.8 , −1.1)	.002	.133
Revision	1.1	0.5	+0.6 (−0.5 , +1.7)	.256	0.5	0.3	0.2 (−0.5 , +0.9)	.564	.481
Enteral access	0.7	1.9	−1.2 (−2.6 , +0.2)	.091	0.5	1.2	−0.7 (−1.6 , +0.2)	.112	.721
Vascular access	3.4	3.0	+0.4 (−1.5 , +2.3)	.671	1.4	1.9	−0.5 (−1.8 , +0.8)	.445	.016
Reoperation	6.1	9.6	−3.5 (−4.9 , −2.0)	<.001	4.6	7.1	−2.5 (−3.8 , −1.3)	<.001	.721
Abdominal wall hernia	1.7	2.6	−0.8 (−1.5 , −0.1)	.023	1.4	2.2	−0.8 (−1.5 , −0.1)	.033	.776
Biliary	3.4	4.1	−0.8 (−2.1 , +0.5)	.254	2.4	2.9	−0.5 (−1.5 , +0.5)	.342	.904
Internal hernia	------	0.4	------	.003	------	0.2	------	.031	.045
Paraesophageal hernia	0.4	0.2	+0.2 (−0.1 , +0.5)	.167	0.3	0.2	+0.06 (−0.3 , +0.4)	.719	.203
Other	1.3	4.1	−2.8 (−3.8 , −1.8)	<.001	1.0	2.9	−1.9 (−2.6 , −1.3)	<.001	.674
Other reintervention	1.5	1.3	+0.2 (−0.5 ,+ 1.0)	.515	0.9	1.2	−0.4 (−1.0 , +0.3)	.248	.034
ED visit	54.7	58.2	−3.5 (−7.4 , +0.5)	.084	32.4	37.4	−4.98 (−8.3 , −1.7)	.003	.157
Rehospitalization, % (95% CI)	25.3	27.8	−2.6 (−5.8 , +0.6)	.117	20.4	23.0	−2.5 (−5.1 , +0.06)	.056	.736

Abbreviation: RYGB, Roux-en-Y gastric bypass

[a] $P_{interaction}$ = *P* value of the interaction term between entitlement group and bariatric procedure.

Table 4:

Instrumental Variable Analysis of 3-Year Safety and Healthcare Utilization Outcomes

Cells with number < 11 are suppressed in accordance with the Medicare data use agreement.

	Disability				Age 65 years or greater				
	Sleeve Gastrectomy, %	**RYGB, %**	**Absolute Risk Reduction, % (95% CI)**	***P* value**	**Sleeve Gastrectomy, %**	**RYGB, %**	**Absolute Risk Reduction, % (95% CI)**	***P* value**	$P_{interaction}$*
Mortality	2.1	3.2	−1.1 (−2.2 , −0.03)	.043	1.8	2.8	−1.0 (−2.1 , +0.1)	.081	.973
Complications	22.2	27.7	−5.5 (−8.5 , −2.6)	<.001	20.1	24.7	−4.6 (−7.6 , −1.7)	.002	.574
Reinterventions	20.1	27.7	−7.6 (−10.7 , −4.6)	<.001	14.0	21.9	−7.9 (−10.7 , −5.2)	<.001	.076
Revision	2.5	1.2	+1.3 (+0.2 , +2.4)	.021	0.7	0.9	−0.2 (−0.8 , +0.4)	.506	.001
Enteral access	1.1	2.9	−1.8 (−3.4 , −0.2)	.024	0.7	2.0	−1.4 (−2.3 , −0.4)	.006	.739
Vascular access	5.6	5.6	−0.01 (−1.7 , +1.7)	.992	3.3	3.6	−0.4 (−1.6 , +0.9)	.580	.398
Reoperation	13.5	23.0	−9.5 (−11.8 , −7.2)	<.001	9.9	18.0	−8.1 (−10.4 , −5.8)	<.001	.597
Abdominal wall hernia	4.9	6.8	−1.9 (−3.4 , −0.4)	.013	4.2	5.8	−1.7 (−3.3 , +0.02)	.052	.998
Biliary	6.4	9.6	−3.2 (−5.0 , −1.4)	<.001	4.4	7.5	−3.1 (−4.6 , −1.6)	<.001	.225
Internal hernia	------	1.2	------	<.001	------	0.7	------	.002	.178
Paraesophageal hernia	1.3	0.7	+0.6 (+0.1 , +1.1)	.019	0.7	0.6	+0.1 (−0.5 , +0.7)	.730	.168
Other	3.4	10.7	−7.2 (−8.8 , −5.7)	<.001	2.4	7.2	−4.9 (−6.0 , −3.8)	<.001	.760
Other reintervention	3.0	2.6	+0.4 (−0.6 , +1.3)	.448	2.0	2.2	−0.2 (−0.9 , +0.5)	.662	.140
ED visit	71.6	77.1	−5.5 (−8.5 , −2.4)	.001	51.7	57.2	−5.5 (−9.1 , −1.9)	.003	.117
Rehospitalization	47.4	52.3	−4.9 (−8.0 , −1.7)	.002	41.8	45.8	−4.0 (−7.5 , −0.5)	.024	.415

Abbreviations: RYGB, Roux-en-Y gastric bypass

[a] $P_{interaction}$ = *P* value of the interaction term between entitlement group and bariatric procedure.