International Journal of Technology Assessment in Health Care, 31:6 (2015), 407–413.

doi:10.1017/S0266462315000653

BEFORE-AND-AFTER STUDY: DOES BARIATRIC SURGERY REDUCE HEALTHCARE UTILIZATION AND RELATED COSTS AMONG OPERATED PATIENTS?

Silvana Marcia Bruschi Kelles
Unimed BH, Health Technology Assessment Group – GATS; Faculdade de Medicina da Universidade Federal de Minas Gerais
silvanakelles@gmail.com

Carla Jorge Machado, Sandhi Maria Barreto
Faculdade de Medicina da Universidade Federal de Minas Gerais, Centro de Pósgraduação

Background: Healthcare use and costs are about 81% higher for morbidly obese individuals compared to non-obese persons, and 47% higher compared to the non-morbidly obese population. The benefits of bariatric surgery for health are well established, but its mid-term impact on healthcare use and costs remains controversial.
Methods: This study examines the trends in healthcare use and costs in a Brazilian cohort during a 4-year period before and after surgery. Healthcare use and direct costs related to inpatients and outpatients were retrieved from a healthcare insurance company database from which all cohort members were selected.
Results: Between 2004 and 2010, 4,006 individuals underwent bariatric surgery. Most patients were female (80%) with a mean age of 36.2 years and a mean body mass index of 42.8 kg/m^2. Elevated blood pressure was present in 38% of cases and diabetes was found in 12.5% of subjects. Hospital admissions increased consistently after surgery, even after excluding hospitalizations for esthetic surgery and pregnancy-related care. The most prevalent conditions in this group were gastrointestinal diseases. Emergency department visits increased after bariatric procedures, in particular for genitourinary and hematologic problems. Adjusted costs were higher after surgery as assessed during a 4-year follow-up period.
Conclusion: Results indicate that costs and hospital admissions after bariatric surgery increase following this procedure, even when elective interventions are excluded. Healthcare providers and policy makers need to be aware that a decrease in obesity-related diseases following bariatric surgery does not reduce healthcare use and costs.

Keywords: Cost analysis, Healthcare services evaluation, Bariatric surgery, Follow-up studies, Morbid obesity

Healthcare utilization and costs are approximately 81 percent higher for morbidly obese individuals compared with nonobese persons and 47 percent higher compared with the nonmorbidly obese population (1;2).

The Brazilian Family Budget Survey (3) of subjects aged 20 years and above has shown that obesity currently affects 12.5 percent of Brazilian males and 16.9 percent of Brazilian females, comprising 18.5 million individuals. The prevalence of morbid obesity—defined as a body mass index (BMI) of 40 kg/m^2 or more—increased by 70 percent over the past 5 years (3). In 2012, 0.8 percent of the population was affected, comprising approximately one million individuals, of which 0.4 percent were male and 1.1 percent were female (Pesquisa de Orçamentos Familiares 2008, unpublished data).

The burden of severe obesity (morbid obesity or a BMI ≥ 35 kg/m^2 with life-threatening comorbidities) is well known, as are the medical benefits of bariatric surgery. This procedure results in greater weight loss compared with other approaches and this outcome persists for at least 10 years. Additionally, weight loss is accompanied by improvement of comorbidities, such as diabetes and elevated blood pressure, and less need for medication. Short-term (up to 2 years) improvements as measured by health-related quality of life assessments have been reported. Long-term (2 to 10 years) effects, however, are less clear (4).

Bariatric surgery is considered a safe procedure, but carries the usual risks and threats of surgical interventions in general. Postoperative adverse events, some of which require further procedures, include leaks at the site of anastomosis, pneumonia, pulmonary embolism, band slippage, and band erosion. Death is rare, but may occur during or after the procedure. Stricture of the anastomosis and reoperations are more frequent in laparoscopic surgery. Wound infections and hernias are more common after open surgery (5).

There are few published papers on the economic gains following bariatric surgery, most of which are controversial. A survey of the literature (using the terms "Bariatric Surgery/economics" [Mesh] OR "Bariatric Surgery/utilization" [Mesh]) yielded papers comparing obese individuals matched with patients undergoing bariatric surgery. Some of these articles

This study was funded by FAPEMIG (Fundação de Amparo à Pesquisa do Estado de Minas Gerais). The authors are grateful to UNIMED BH for providing data from its database. The authors also thank Doctor Fernando Biscione for his invaluable assistance in organizing the data, and librarians Mariza Talim and Mariana Ribeiro for their support. Professor Sandhi Barreto has a fellowship from CNPq and from FAPEMIG.

showed that the average total cost was higher in the operated group (6;7). Conversely, other articles revealed that total healthcare costs were higher in the control group (8–10). A comparison of two cohorts of obese patients with diabetes showed that medication costs decreased significantly in the operated group (11). Before-and-after studies have shown that total costs were higher after surgery (12–15). The cohorts in the majority of these studies were health-insured patients (6;8;9;11–13), rather than patients in public healthcare (7;10;14;15). Furthermore, follow-up was consistently shorter in studies of individuals treated in public healthcare settings. Therefore, longer follow-up periods are needed to assess costs and outcomes in the surgical treatment of these patients in low- and middle-income countries to fully understand the advantages and economic benefits of bariatric surgery.

In this study, we compared severely obese patients before and after bariatric surgery to investigate differences in healthcare utilization and costs. The study period was 2004 to 2011. Our hypothesis was that healthcare utilization and costs would be lower following bariatric surgery because of decreases in bodily weight and comorbidities.

METHODS

The study sample consisted of health-insured patients (by an insurance company that provides health insurance to over a million individuals) from Belo Horizonte, a city in Southeastern Brazil, who underwent surgery at any time between 2004 and 2010. Enrolment required the following criteria: subjects aged at least 18 years with a BMI of at least 40 kg/m^2 or at least 35 kg/m^2 plus two comorbidities (generally elevated blood pressure, diabetes, and/or sleep apnea), with medical and psychological clearance for surgery, and with healthcare insurance during at least 1 month before and after surgery. The Roux-en-Y gastric bypass procedure (RYGB), the only technique approved by the healthcare provider between 2004 and 2010, was done in all patients.

The healthcare utilization pattern before-and-after surgery, perioperative events, long-term surgical complications, and cost-utility data were taken from the health insurance company database. Available variables were sex, age, procedure codes for hospital admissions, emergency department visits, and diagnostic codes (ICD 10th revision), healthcare costs and supplementary preoperative audits of the BMI and comorbidities for each patient. Healthcare expenses included all payments to physicians and healthcare institutions. Outpatient prescriptions were not included.

Time zero (T = 0) was defined as the date of bariatric surgery. The month before surgery was defined as "-1" and consisted of healthcare utilization and costs during the month up to the day patients were admitted into hospital for surgery. The month after surgery was defined as "+1" and consisted of healthcare utilization as costs during the month after the day patients were discharged following bariatric surgery. Patients were monitored equally before and after surgery. For instance, a patient entering the cohort 12 months before surgery and declining health insurance 5 years after bariatric surgery would have healthcare utilization data gathered only for 1 year before and 1 year after surgery. Our aim was to have each patient yielding a similar observation period before and after surgery. This approach also avoids inflated healthcare costs after surgery in less healthy patients, who tend to remain covered by healthcare insurance for longer time frames; the opposite also applies. The unit was "patient-year," which expressed the incidence of pertinent events for this study. These rates were calculated by dividing the number of incidents over the total time patient were at risk during the same period.

Costs were measured up to 48 months before and up to 48 months after surgery. To minimize the influence of surgery on the utilization and cost profile of these patients, in the context of a sensitivity analysis, expenses during 6 months immediately before and 6 months immediately after surgery were removed; these expenses could reflect preparation costs of surgery and immediate postoperative care. Hospital admissions were recorded in the database as admission and discharge dates. The follow-up period continued until one of the following, whichever occurred first: death of the patient, loss of healthcare insurance, and the end of the study (December 31, 2011). Deaths in hospital or within 30 days of surgery were recorded in the healthcare insurance company database.

The diagnoses of hospital admissions and emergency department visits before and after bariatric surgery were recorded as the rate of patient-years of observation, and were categorized into ICD-10 groups of diseases per bodily system as follows: (i) digestive system; (ii) circulatory system; (iii) genitourinary system; (iv) endocrine, nutritional, and metabolic conditions; (v) musculoskeletal system and connective tissue conditions; and (vi) others.

Additional disease groups were applied for emergency department visits, as follows (i) respiratory system; (ii) skin and subcutaneous tissue conditions; (iii) certain infections and parasitic infestations; (iv) conditions related to blood and blood-forming organs and of the immune system; (v) nervous system; (vi) mental and behavioral conditions; (vii) injury, poisoning, and other consequences of external causes; and (viii) others. The cost unit of analysis was the patient.

Healthcare costs for each bariatric surgery patient were compiled separately, and total costs were reported as consolidated expenses incurred by the health insurance company to health providers before and after bariatric surgery. The mean cost per person, per month, or per semester was obtained by dividing the total costs of all patients by the number of eligible patients for the same period. The cost of bariatric surgery admission was not included in these calculations.

Descriptive cost analysis was presented including and excluding costs due to pregnancy and/or esthetic surgery. Costs

https://doi.org/10.1017/S0266462315000653 Published online by Cambridge University Press

were inflation-adjusted for December 2011 in Brazilian currency. Adjustment was based on the Consumer Price Index (IPCA) and on the exchange rate for U.S. dollars (USD) according to the Brazilian Central Bank exchange rate on December 2011 (USD 1.00 = R$ 1.88)

Statistical Analysis

A descriptive analysis was made of the comorbidities present before surgery (elevated blood pressure, diabetes, joint diseases, and sleep apnea). We also assessed subgroups with a BMI of 50 kg/m^2 or more, and subjects aged 50 years and above.

Patient data were presented as frequency distributions for categorical variables, and mean and standard deviations for continuous variables. Data before were compared with data after surgery to estimate changes in healthcare use as a result of surgical treatment of obesity.

The distribution of variables was tested for normalcy. Outcome measures included differences between the mean number of hospital admissions, emergency department visits, and costs per patient/year, for each year. The Wilcoxon signed-rank test was used to examine differences between continuous variables. Overall costs were presented as average payments incurred by the health insurance company for every operated patient per semester. To a best-line fit calculation, curve and the corresponding quadratic equation with its R^2 value was included to find the best model for analyzing cost trends.

The EPI Info TM version 6.04 were used for data entry. The Stata Statistical Software Release 12 (College Station, TX: Stata Corp LP) was used for data analysis. The Ethics Research Committee of the Minas Gerais Federal University (COEP UFMG ETIC—0074.0.203.000.11) approved this study. Signed informed consent was not required.

RESULTS

There were 4,006 subjects enrolled in this study. These patients underwent bariatric surgery between 2004 and 2010. The follow-up period continued until December 31, 2011, or until death or exclusion from the health insurance coverage, whichever occurred first. The cohort consisted mostly of females (80 percent). One or more comorbidities was preset in 51 percent of cases. The median duration of follow-up after enrollment in the cohort (the day of surgery) was 4 years, and the total number of person-years of observation was 75,942. At the baseline, the mean and median ages were, respectively, 36.2 years (SD 10.3) and 34.2 years. The mean and median BMI were, respectively, 42.8 kg/m^2 (SD 4.8) and 42.0 kg/m^2. There were 528 (13.2 percent) patients aged 50 years or more. There were 383 patients (9.6 percent) with a BMI $\geq$ 50 kg/m^2. Before surgery, 37.9 percent patients presented with elevated blood pressure, 12.5 percent had diabetes, 9.2 percent had joint diseases, and 3.6 percent had sleep apnea. The Supplementary Table 1 presents the baseline characteristics of the 4,006 study patients. This table also shows the characteristics of subjects in other published papers assessing costs and health insurance use after bariatric surgery.

There were 23 deaths (0.6 percent) within the first month after surgery. The number of hospital admissions during the study period was 2.605; of these, 854 were before and 1,751 were after surgery ($p < .001$). The number of hospital admission, for the entire study period was 1,971 after excluding pregnancy-related hospital admissions before and after bariatric surgery and esthetic surgery after bariatric surgery. Of these, 37.5 percent were before and 62.5 percent were after bariatric surgery ($p < .001$). The rate is 11.20 hospital admissions per 1,000 patient-years before bariatric surgery, and 23.06 hospital admissions per 1,000 patient-years after bariatric surgery ($p < .001$). If procedures related to pregnancy and esthetic surgery are excluded, the rates were 9.74 per 1,000 patient-years before and 16.21 per 1,000 patient-years after surgery. The full number of emergency department visits was 10,597 before bariatric surgery, and 9,587 visits after surgery. The incidence rates of emergency department visits per 1,000 patient-years during the 4-year follow-up period (Table 1) were 139.54 before surgery and 126.24 after surgery ($p = .23$). The incidence rate of emergency department visits was lower in the first 2 years, but tended to increase 3 years and beyond after surgery; this increase was statistically significant.

The hospital admission incidence rates per 1,000 patient-years in selected groups of diseases are shown on Table 2. These diagnoses accounted for 60 percent of hospital admissions. Admission rates due to digestive, endocrine and metabolic diseases increased significantly throughout the study period. There was no statistical difference in hospital admission rates for circulatory and genitourinary diseases.

The rate of emergency department visits due to genitourinary, hematologic, and specific immune disorders increased significantly within the first year following bariatric surgery. Circulatory and respiratory diseases were less frequent postoperatively. Supplementary Table 2 shows additional data.

Overall costs increased during follow-up. Figure 1 shows average health insurance payments per patient before and after surgery, excluding 6 months before and 6 months after surgery. The continuous line is the total average cost per patient during follow-up. The dotted line is costs except for esthetic surgery and pregnancy-related procedures. The two lines showing post-surgical costs trended upward. The estimated cost trend showed that costs initially increase with time; eventually the rate of increase diminishes and at some point start to decrease. On average, expenses were higher after bariatric surgery.

The average costs of the RYGB per patient was USD 4,951.28. Table 3 shows the average costs per patient per year before and after bariatric surgery. Altogether, there is a statistically significant increase in costs per patient after bariatric surgery, even after excluding esthetic surgery and pregnancy-related expenses. The average costs per patient were statistically

https://doi.org/10.1017/S0266462315000653 Published online by Cambridge University Press

Table 1. Inpatient Hospital Admissions and Emergency Department Visits before and after Bariatric Surgery in 4,006 Patients between 2004 and 2011

	Follow-up period														
	1st Year			2nd Year			3rd year			4th year			Total		
Characteristics	Before	After	*p*-Value [a]	Before	After	*p*-Value [a]	Before	After	*p*-Value [a]	Before	After	*p*-Value [a]	Before	After	*p*-Value [a]
Patients/year under observation in the cohort [b]		17,868			28,341			20,689			9,045			75,942	
Admission per 1,000 patient /years	22.44	38.67	0.005	10.51	26.60	0.002	5.75	12.28	0.003	3.98	5.75	0.036	11,21	23.06	<0.001
Admission per 1,000 patient /years with exclusions [c]	20.54	37.67	0.004	8.79	13.94	0.012	4.69	6.24	0.033	2.99	3.76	0.091	9.74	16.21	<0.001
ER visits per 1,000 patient /years	366.19	290.91	0.050	97.07	98.02	0.695	48.62	58.58	0.002	32.84	44.11	0.003	139.54	126.24	0.226

[a] Wilcoxon signed-rank test.
[b] Each patient contributed equal time of follow-up before and after surgery.
[c] Excluded hospital admissions related to pregnancy or esthetic surgery.

higher among male patients, those with a BMI ≥ 50 kg/m^2, those aged ≥ 50 years, and those with joint diseases. Supplementary Table 3 shows average costs per patient per year.

DISCUSSION

Our results showed consistently increased incidence rates for hospital admissions and the mean healthcare costs per patient up to 4 years after bariatric surgery. An important outcome supporting RYGB for the treatment of obesity is the improvement resolution of obesity-related comorbidities such as diabetes, sleep apnea, and high blood pressure (14). Therefore, fewer hospital admission are to be expected after the surgery, at least for the short- and mid-term. However, if hospital admission is considered as a proxy for diseases, an increase in admission rates suggests lack of improvement or worsening of health after surgery. Our results suggest that the surgical procedure itself may be a significant cause of increased hospital admissions after surgery, at least within a 4-year follow-up period.

There was a consistent increase in digestive, endocrine, nutritional, and metabolic diseases. These findings concur with those of other authors (10;16) describing increased healthcare utilization after bariatric surgery within the first 6 years after bariatric surgery. Gastrointestinal complications of obesity surgery can occur at any time. According to Abell and Minocha (17), these complications are dumping, vitamin and mineral deficiency, vomiting and nausea, staple line failure, infection, stenosis, bowel obstruction, ulceration, and splenic bleeding or injury. Weight loss, intestinal bacterial overgrowth, and diarrhea may occur.

Besides additional hospital admissions for treating diseases and for esthetic surgery after massive weight loss, there probably is a delayed demand for other elective procedures which would have been postponed because of obesity. There is evidence of an increased number of hip or knee replacements as individuals become more active after surgery. It is likely that such operations would not have taken place if patients had not lost weight significantly (18).

An evaluation of emergency department visits revealed that genitourinary and hematologic diseases are more frequent after bariatric surgery. In the study by Encinosa et al. (19), genitourinary diseases (urinary tract infections and calculi) were found in 10 percent of emergency department visits. Hematologic diseases are probably due to iron-deficiency anemia, a condition that may affect as many as two-thirds of postbariatric surgery patients (20;21). We found downward trends in emergency department visits for circulatory, respiratory, and musculoskeletal diseases, possibly in line with an expected decrease of comorbidities (22).

Several reasons may explain why costs after bariatric surgery remain high. Our analysis indicates that health insurance costs increase significantly after bariatric surgery up to 4 years

Table 2. Admission Rate per 1,000 Patient-Years, Categorized by ICD-10 Codes, before and after Bariatric Surgery, by Year of Assessment in the Study

	1st Year			2nd Year			3rd Year			4th Year		
ICD 10 group or description	Before	After	*p*-Value[a]	Before	After	*p*-Value[a]	Before	After	*p*-Value[a]	Before	After	*p*-Value[a]
Diseases of the digestive system	28.52	184.33	0.002	16.50	68.29	0.003	2.93	18.17	0.002	3.44	8.54	0.173
Diseases of the circulatory system	63.70	117.43	0.534	20.83	24.88	0.433	11.60	11.45	0.971	4.51	5.75	0.686
Diseases of the genitourinary system	67.61	77.93	0.534	16.53	25.42	0.074	10.86	10.64	0.866	3.78	6.48	0.465
Endocrine, nutritional and metabolic diseases	14.01	58.43	0.123	1.25	43.52	0.002	2.24	25.60	0.003	0.00	13.44	0.018
Diseases of the musculoskeletal system and connective tissue	29.07	28.41	0.767	10.15	23.22	0.013	4.26	11.28	0.074	3.71	8.68	0.499
Others[b]	129.38	460.18	0.239	60.82	133.30	0.002	35.42	62.69	0.015	29.68	20.72	0.086

[a] *p*-Value, Wilcoxon signed-rank test.

[b]Others included: diseases of the eyes, ears, mastoid, congenital malformation, deformities, external causes of morbidity and mortality, pregnancy, childbirth and the puerperium, injury, poisoning and certain other consequences of external causes; diseases of skin and subcutaneous tissue; diseases of the respiratory system; neoplasms, mental and behavioral disorders; symptoms, signs, and abnormal clinical and laboratory findings; infectious or parasitic disorders not elsewhere classified.

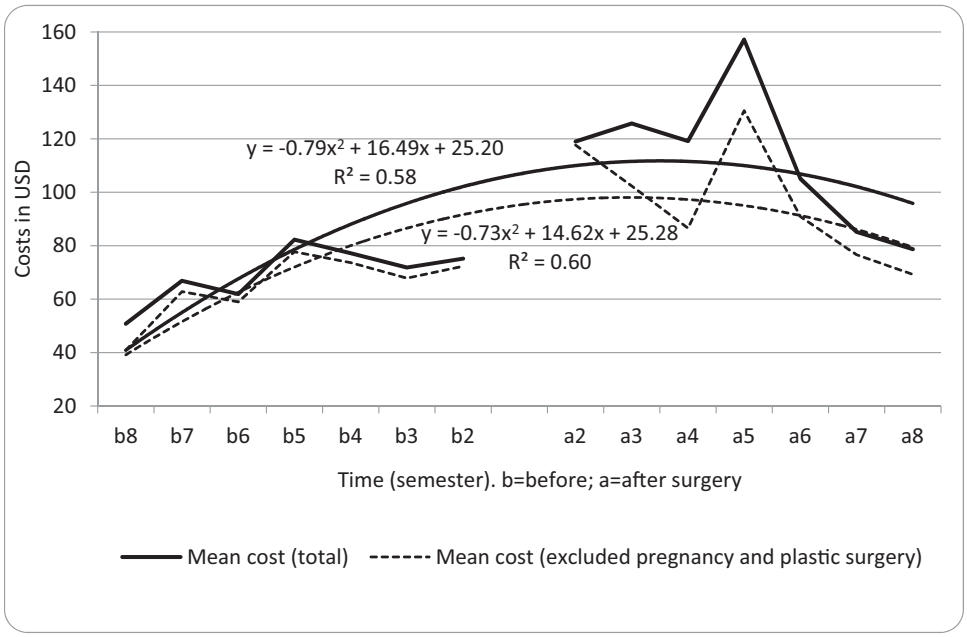

Figure 1. Average healthcare costs per patient and per semester, before and after bariatric surgery, during a 4-year follow-up period.

after this procedure. This finding concurs with published studies. Several papers have reported increased costs after bariatric surgery in before-and-after studies (12–15) and in comparative studies between operated patients and matched non-operated controls (6–10;16). On the other hand, there seems to be a decrease in costs after bariatric surgery if out-of-pocket expenses with medication are included in the analysis (11;16).

Using information based on data from health insurance claims may be a challenge. Clinical outcomes are better than financial metrics for assessing healthcare. The database we used in this study is used for payment of healthcare by the health insurance company. Although information about healthcare use and costs after bariatric surgery could be better evaluated by randomized controlled trials, such a study has not been conducted and probably will never be due to ethical concerns. Thus, we rely on observational studies as the best available evidence on this topic. Each type of study has its own bias; within-group comparisons are often limited by a duration bias. To minimize this effect, for each patient we compared a time period before bariatric surgery with a similar time period after surgery to avoid any effect resulting from duration of observation on healthcare use, given that such use is time-dependent. This strategy also yielded a consistent control group where each operated patient was his or her own control.

https://doi.org/10.1017/S0266462315000653 Published online by Cambridge University Press

TABLE 3. Average Costs (in USD) per Patient per Year, and Percent of Increase/Decrease Costs before and after Bariatric Surgery, in 4,006 Patients Undergoing Bariatric Operation, between 2004 and 2011

	4 Years before and after surgery #			
Characteristics	Before	After	*p*-Value [a]	% Increase/decrease costs
Average total costs per person per year USD	69.42	112.86	<0.001	62.58
Average total costs per person per year USD[b]	64.88	96.27	<0.001	48.38
Average total costs per patient characteristics				
Male (n = 805)	54.04	98.73	<0.001	82.70
Female (n = 3201)	73.18	116.17	<0.001	58.75
BMI < 50 kg/m^2 (n = 3,623)	70.92	114.98	0.002	62.13
BMI ≥50 kg/m^2 (n = 383)	49.36	82.63	<0.001	67.40
Age <50 years (n = 3478)	61.46	100.73	0.001	63.90
Age ≥50 years (n = 528)	110.49	172.23	<0.001	55.88
Average total costs per patients with comorbidities				
Hypertension (n = 1,518)	83.84	137.29	<0.001	63.75
Diabetes (n = 501)	114.78	124.53	0.339	8.50
Hypertension and diabetes (n = 329)	122.13	133.41	0.464	9.24
Diseases of the joints (n = 370)	86.01	137.95	<0.001	60.39
Sleep apnea (n = 146)	126.08	116.97	0.253	-7.23

#Excluding 6 months immediately before and immediately after bariatric surgery.
[a] *p*-Value Wilcoxon signed-rank test.
[b] Excluding in-hospital care of pregnancy and esthetic surgery.

Few studies on healthcare costs after bariatric surgery in middle or low-income countries have been conducted. The present study is the first mid-term assessment of the outcomes after bariatric surgery in a large Brazilian cohort. Cumulative evidence in developed countries suggests that no economic benefit results from weight-loss surgery (6;7;11–15;23). It should be noted that our cohort was younger and had a lower average BMI as well as more favorable comorbidity profile compared with other cohorts in the majority of published papers. There is no doubt that bariatric surgery improves the health and well-being of most morbidly obese patients; however, it does not seem to results in cost savings for healthcare insurance companies (6;7;11–15;23).

Our data describe patients covered by a private healthcare insurance company that has no restrictions on coverage. Approximately one-fourth of the Brazilian population (which is close to 200 million individuals) has private healthcare insurance. The healthcare use pattern may be different in patients treated under the Brazilian Universal Public Health System. As bariatric surgery is applied to treat impaired health, rather than merely an esthetic procedure, postoperative care will be given even if access to public healthcare is more difficult. The outcomes and costs reported in this study may support estimates made by private and public healthcare providers to meet the healthcare and funding requirements for assisting these patients.

CONCLUSION

Bariatric surgery does not reduce overall mid-term healthcare costs and use. Our data may be of interest to managed-care decision makers. Further studies may offer a broader assessment of the healthcare and the costs of bariatric surgery, including quality of life and medication use. This may yield a more comprehensive evaluation of changes before and after surgery.

SUPPLEMENTARY MATERIAL

Supplementary Table 1–3
http://dx.doi.org/10.1017/S0266462315000653

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Flegal KM, Carrol MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999–2000. *JAMA*. 2002;288:1723-1737.
2. Arteburn DE, Maciejewski ML, Tsevat J. Impact of morbid obesity on medical expenditures in adults. *Int J Obes*. 2005;29:334-339.

3. Brasil, Ministério da Saúde, Ministério do Planejamento, Orçamento e Gestão. *Pesquisa de Orçamentos Familiares 2008–2009: Antropometria e estado nutricional de crianças, adolescentes e adultos no Brasil*. Brasília: IBGE; 2009:130.
4. Colquitt JL, Picot J, Loveman E, Clegg AJ. Surgery for obesity. *Cochrane Database Syst Rev*. 2009;15:CD003641.
5. Flum DR, Belle SH, King WC, et al. Longitudinal Assessment of Bariatric Surgery (LABS) consortium. *N Engl J Med*. 2009;361:445-454.
6. Maciejewski ML, Livingston VA, Smith VA, et al. Health expenditures among high-risk patients after gastric bypass and matched controls. *Arch Surg*. 2012;147:633-640.
7. Agren G, Narbro K, Jonsson E, et al. Cost of in-patient care over 7 years among surgically and conventionally treated obese patient. *Obes Res*. 2002;10:1276-1283.
8. Cremieux PY, Buchwald H, Shikora A, et al. A study on the economic impact of bariatric surgery. *Am J Manag Care*. 2008;14:589-596.
9. Finkelstein EA, Allaire BT, Burgess SM, Hale BC. Financial implications of coverage for laparoscopic adjustable gastric banding. *Surg Obes Relat Dis*. 2011;7:295-303.
10. Christou NV, Sampalis JS, Liberman M, et al. Surgery decreases long-term mortality, morbidity and health care use in morbidly obese patients. *Ann Surg*. 2004;240:416-424.
11. Klein S, Ghosh A, Cremieux PY, Eapen S, McGavock TJ. Economic impact of the clinical benefits of bariatric surgery in diabetes patients with BMI≥ 35 kg/m^2. *Obesity*. 2011;19:581-587.
12. Bleich SN, Chang HY, Lau B, et al. Impact of bariatric surgery on health care utilization and costs among patients with diabetes. *Med Care*. 2012;50:58-65.
13. McEwen LN, Coelho RB, Baumann LM, et al. The cost, quality of life impact, and cost-utility of bariatric surgery in a managed care population. *Obes Surg*. 2010;29:919-928.
14. Zingmond DS, McGory MI, Ko CY. Hospitalization before and after gastric bypass surgery. *JAMA*. 2005;294:1918-1924.
15. Weiner JP, Goodwin SM, Chang HY, et al. 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. *JAMA Surg*. 2013;148:555-562.
16. Neovius M, Narbro K, Keating C, et al. Health care use during 20 years following bariatric surgery. *JAMA*. 2012;308:1132-1141.
17. Abell TL, Minocha A. Gastrointestinal complications of bariatric surgery: Diagnosis and therapy. *Am J Med Sci*. 2006;331:214-218.
18. Kulkarni A, Jameson SS, Woodcock S, Muller S, Reed MR. Does bariatric surgery prior to lower limb joint replacement reduce complications? *Surgeon*. 2011;9:18-21.
19. Encinosa WE, Bernard D, Chen CC, Steiner CA. Healthcare utilization and outcomes after bariatric surgery. *Med Care*. 2006;44:706-712.
20. Drygalski A, Andris DA. Anemia after bariatric surgery: more than just iron deficiency. *Nutr Clin Pract*. 2009;24:217-226.
21. Vargas-Ruiz AG, Hernández-Rivera G, Herrera MF. Prevalence of iron, folate and vitamin B12 deficiency anemia after laparoscopic Roux-en-Y gastric bypass. *Obs Surg*. 2008;18:288-293.
22. Ricci C, Gaeta M, Rausa E, et al. Long-term effects of bariatric surgery on type II diabetes, hypertension and hyperlipidemia: A meta-analysis and meta-regresion study with 5 year follow-up. *Obes Surg*. 2015;25:397-405.
23. Livingston EH. Is bariatric surgery worth it? Comment on "Impact of bariatric surgery on health care costs of obese persons". *JAMA Surg*. 2013;148:56.

https://doi.org/10.1017/S0266462315000653 Published online by Cambridge University Press