

## **Six-Month Readmissions Following Bariatric Surgery: Results of a Nationwide Analysis**

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## **Abstract**

**Background:** Morbidity and mortality after laparoscopic bariatric surgery have steadily declined over the last two decades. National data on the rates at which these patients may require return to the hospital beyond 30 days are lacking. We aimed to determine the national burden and causes of readmission after the three most common bariatric procedures in the United States.

**Methods:** All morbidly obese adult patients (>18 years old) that underwent a laparoscopic adjustable gastric banding (LAGB), laparoscopic sleeve gastrectomy (LSG), or laparoscopic gastric bypass (LGBP) between 2010-2015 were identified using ICD-9-CM codes from the Nationwide Readmission Database (NRD). The NRD permits longitudinal tracking of patients between hospital admissions and allows for nationally-weighted estimates. The primary outcome was 180-day readmission, and secondary outcomes included causes, mortality, time to readmission, costs and procedures during readmission. Multivariate logistic regression models were used to determine factors associated with increased 180-day readmission adjusting for differences in patient and hospital characteristics.

**Results:** Records from 228,043 patients were identified, of which 10.1%, 36.1% and 53.9% underwent LAGB, LSG and LGBP, respectively. The overall 180-day readmission rate was 10.8% (LAGB 8.3%, LGS 7.8% and LGBP 13.2%). Readmission analysis showed that 64.5% were directly related to the index procedure, 31.2% were readmitted to a different hospital, the median time to readmission was 28 days (IQR 9-77), 23.9% had a gastrointestinal procedure and 0.48% died within 180-day readmissions. Factors independently associated with increased readmission were higher comorbidities [CCI<sub>≥</sub>2, OR 1.32 (95% confidence interval 1.22-1.44)], Medicare [1.84, [1.72-1.97]] or Medicaid [1.60, (1.48-1.73), relative to private] insurance, moderate [1.09, (1.03-1.15)] or major [1.33, (1.13-1.56), relative to minor] NRD-provided

severity of illness, non-resident of state where they were initially admitted [1.49, (1.31-1.69)], discharge to other than home [home health care 1.70 (1.46-1.97); short-term hospital 1.70, (1.46-1.97)], admission to private hospital [1.11, (1.01-1.22), relative to non-profit], prolonged length of stay [1.81, (1.70-1.92)], serious adverse event during index admission [1.20, (1.02-1.42)]. Patients who were readmitted had an incremental mean difference of \$15,781 (95% CI \$15,168 - \$16,394.4;  $p < 0.001$ ) in total costs.

**Conclusion:** Readmissions after bariatric surgery continue to occur even 6 months after discharge. Most of them are directly related to the index procedure. Almost a fourth of those readmitted required a procedure and almost a third presented to a different hospital than their initial surgery. They carry a significant burden for the healthcare system and may impair quality of life for patients. Strategies targeted to prevent readmissions beyond the traditional 30-day benchmark may be warranted in this population.

## **Introduction**

In the United States, the number of bariatric procedures continues to increase every year. The American Society for Metabolic and Bariatric Surgery estimated an increase in bariatric surgery from 158,000 cases in 2011 to 228,000 cases in 2017.<sup>1</sup> Laparoscopic gastric band (LGB), laparoscopic gastric sleeve (LGS) and the laparoscopic gastric bypass (LGBP) are the most prevalent.<sup>1</sup> While these procedures have proven to be safe, have low complication rates,<sup>2</sup> and have a short length-of-stay,<sup>3</sup> recovery may be more difficult in a proportion of patients who require a return to the hospital.

Readmission is one of the current quality metrics and readmission reduction is one of the strategies proposed by the Centers for Medicare and Medicaid Services (CMS) in an effort to improve quality of care and reduce healthcare cost.<sup>4</sup> The 30-day readmission rate after bariatric surgery has been reported to range between 4-10 %, <sup>5-11</sup> and there is recent data which suggest that the risk for readmission after bariatric procedures extends beyond the 30-day benchmark.<sup>12</sup> Over a third of patients present to the ED at least once within 1 year,<sup>7,12</sup> and more than a quarter (26%) get readmitted within 2 years.<sup>6</sup> Moreover, readmissions are costly and tend to be linked to expensive interventions. They can increase average costs of bariatric procedures up to a 2.5-fold.<sup>13</sup> While these prior studies have characterized readmissions after bariatric surgery fairly well, they have been limited by single-institution or statewide data, nationwide convenient sampling (such as the American College of Surgeons National Surgical Quality Improvement Program database), or by the inability to track readmissions to different hospitals.

To date, there is no data on the rates at which these patients may require return to the hospital beyond 30 days from a nationally-representative cohort. The objective of this study was

to determine the national burden and causes of 180-day readmission after the three most common bariatric procedures in the United States.

## **Methods**

### *Study population*

Using the 2010-2015 Nationwide Readmission Database (NRD), we included patients undergoing bariatric procedures as defined by the International Classification of Diseases, Ninth Revision (ICD-9), procedure codes for laparoscopic gastric restrictive procedure (44.95, referred to as laparoscopic gastric band [LGB]), laparoscopic vertical gastrectomy (43.82, referred to as laparoscopic gastric sleeve [LGS]) and laparoscopic gastroenterostomy (44.38, referred to as laparoscopic gastric bypass [LGBP]), who also had an ICD-9 diagnosis code of morbid obesity (278.01) during the index admission. Patients with incomplete follow up were excluded. For calendar years 2010-2014, data from January until June were used to allow for a follow-up of 180 days. Data from 2015 quarter 4 were excluded for analysis uniformity given the nationwide transition from ICD-9 to ICD-10 codes that occurred during this period. Therefore, for calendar year 2015, only data from January until March was used. Patients aged <18 years and transfers were excluded. Patients in strata with single units were excluded to allow statistical tests in weighted analyses.

### *Data source*

The NRD was developed through a Federal-State-Industry partnership sponsored by the Agency for Healthcare Research and Quality and is comprised of data collected from all hospitalizations occurring in each of the 27 contributing states. Unweighted, it contains data from approximately 17 million discharges each year. The NRD contains sampling weights to

create national estimates of readmissions in the United States. It comprises data on individuals of all ages, all payers plus the uninsured. There are more than 100 clinical and nonclinical variables available for each hospital stay, including demographics, payer, International Classification of Diseases, Clinical Modification 9th Edition diagnosis and procedure codes, length of stay, discharge disposition, timing between admissions for patients, identification of transfers, same-day stays, identification of patients who reside within the state, hospital characteristics (size, teaching status, ownership status, urban-rural designation).<sup>14</sup>

#### *Demographic, Clinical and hospital related characteristics*

The demographic, clinical and hospital-associated variables analyzed included age, gender, payer (Medicare, Medicaid, private, self-pay, no charge, other), zip code income quartile (0-25<sup>th</sup> percentile, 26-50<sup>th</sup> percentile, 51-75<sup>th</sup> percentile and 76-100<sup>th</sup> percentile), NRD-provided risk of mortality (minor, moderate, major or extreme likelihood of dying), NRD-provided severity of illness (minor loss, moderate loss, major loss or extreme loss of function), index hospital stay disposition (home/routine; home with home health care; short-term hospital, skilled nursing facility (SNF), intermediate care facility [ICF] or another type of facility; against medical advice), Charlson Comorbidity Index (CCI, <2 or ≥2), prolonged length of stay (>75<sup>th</sup> percentile), type of bariatric procedure, hospital ownership (government; private not-profit; private, invest-own), bedsize of hospital (small, medium or large), teaching status (metropolitan non-teaching, metropolitan teaching, non-metropolitan) and hospital urban-rural designation.

#### *Outcome measures*

The primary outcome was the 180-day readmission rate after the targeted bariatric procedures. This rate was a proportion of patients who were subsequently admitted to any-hospital within 180 days of discharge amongst the total number patients who underwent bariatric

procedures. For readmission analysis purposes, patients who died during the index admission were excluded ( $n=117$ , 0.001% of the entire cohort), and patients with multiple readmissions during the study period were only counted once. We identified readmissions “likely related” to bariatric procedures using the framework of a prior Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) study. We matched the diagnoses listed in their study as causes of readmissions “likely related to index procedure” to corresponding ICD9-CM diagnosis codes (Appendix 1).<sup>15</sup> The percentage of readmissions directly related to each bariatric procedure was reported. The secondary outcomes were reason for readmission, readmission to different hospital, days to readmission, gastrointestinal procedures category during readmission (given by the first two ICD-9 procedure code group), total costs, and mortality at time of readmission, all within 180 days. The reason for readmission was defined as the first NRD-defined “not chronic condition” ICD-9 diagnosis code upon readmission or by the primary ICD-9 diagnosis code upon readmission whenever there were no ICD-9 diagnoses codes classified as “not chronic condition”. The reasons for readmission were clustered by the 3-code ICD-9 diagnosis group for ranking purposes and were stratified according to type of bariatric procedure. The 30-day readmission rate was also included as a secondary outcome given that this is the standard CMS readmission benchmark.

#### *Inpatient utilization burden, estimation of total costs*

The NRD provides charges for each admission, which were converted to costs using HCUP-provided cost-to-charge ratios. Total costs were obtained for those patients who were readmitted by adding the cost of the index admission to the costs of their readmission within 180 days. These costs were normalized to US dollars in 2015 using the Consumer Price Index.

Aggregate costs of the entire cohort as well as for each subgroup were estimated and annualized as a measure of inpatient utilization burden.

### *Statistical analysis*

Descriptive statistics were used to analyze demographic, clinical and hospital characteristics, as well as for readmission rates and most common causes for readmission. Risk-adjusted multivariable logistic regression was used to determine factors associated with increased 180-day readmission. Risk-adjusted generalized linear models followed by post-estimation calculations of average marginal effects were used to obtain predicted mean differences in costs (incremental costs) with 95% CI between non-readmitted and readmitted patients. Potential confounders were identified *a priori* and those with *p* values <0.20 were included in the model. NRD survey weights were used to generate national estimates. Statistical significance was set at  $P < 0.05$ . All the analyses were performed using Stata Statistical Software, Release 15 (College Station, TX). The present study was approved by the Thomas Jefferson University Institutional Review Board.

### **Results**

A total of 228,043 patients underwent laparoscopic bariatric surgery during the study period. Univariate analysis showed that patients who were readmitted were more likely to be older (mean [SD], 46 (12) vs. 45 (12);  $p < 0.001$ ), with more comorbidities (CCI  $\geq 2$ , 19.8% vs. 11.5%), a higher proportion of public insurance and lower proportion of private insurance (Medicare, 27.9% vs. 16%; Medicaid, 16.1% vs. 11.7%; private insurance 49.9% vs. 64.6%;  $p < 0.001$ ), and differed in terms of socioeconomic status given by median household income ( $p < 0.001$ ). This cohort also had a higher risk of mortality and severity of illness ( $p < 0.001$ ), were

less likely to be residents from the same state (94.1% vs. 92%;  $p<0.001$ ), less likely to be discharged home (94.6% vs. 98%;  $p<0.001$ ), more likely to be admitted to a large hospital (63.5% vs. 58.9%;  $p<0.001$ ), more likely to have prolonged length of stay (31.7% vs. 16.5%;  $p<0.001$ ) and a serious adverse event during the index admission (5% vs. 1.7%;  $p<0.001$ ; Table 1).

Readmission rate at 30 and 180 days were of 5.4% and 10.8%, respectively. The bariatric procedure with higher readmission rate was LGBP (13.2%), followed by LGB (8.3%) and LGS (7.8%). Readmission analyses demonstrated that 31.2% of readmissions occur to a different hospital. The median time to readmission was 28 days (IQR 9-77). A total of 23.9% of patients underwent a gastrointestinal intervention at the time of readmission. Of these, the most common were “operations on the stomach” (39%); “repair of hernia” (15.9%); “incision, excision and anastomosis of intestine” (10.4%); “incision and excision of stomach” (8.9%); “other operations on abdominal region” (5.8%); “operations on liver” (4.9%). The mortality rate within 180-day readmissions was 0.5% (Table 2). Relative to 180-day readmissions, 21% of readmissions occur during the first week of discharge, 12% on the second week, 9% on the third week and 7% on the fourth week, reaching about half (50.6%) at 30-days (Figure 1).

The most common causes for readmission included complication of procedure involving implant, complication of procedure (such as of postoperative infection; hemorrhage, hematoma, seroma; etc.), disorders of fluid, electrolyte, and acid-base balance, symptoms involving digestive system and complications affecting digestive or cardiac system (Table 3).

Multivariate logistic regression showed the factors associated with increased 180-day readmission (Table 4). LGB and LGS were 35% and 38% less likely to be readmitted compared to LGBP. Factors independently associated with increased readmissions were higher

comorbidities [CCI<sub>≥</sub>2, OR 1.32 (95% confidence interval 1.22-1.43)], Medicare [1.86, [1.73-1.99]] or Medicaid [1.61, (1.48-1.74)] insurance, moderate [1.09, (1.03-1.15)] or major [1.34, (1.14-1.57)] loss of function, moderate mortality risk [1.24 (1.10-1.34)], non-resident of where they were initially admitted [1.47, (1.30-1.67)], discharge to other than home (p<0.01), admission to private invest-own hospital [1.11, (1.01-1.22)], prolonged length of stay [1.81. (1.70-1.92)], and serious adverse event during index admission [1.20, (1.02-1.42)]. Factors independently associated with decreased 180-day readmissions included LGB and LGS relative to LGBP, self-pay/uninsured relative to private insurance, and elective admission status (Table 4).

#### *Inpatient utilization costs*

The total costs mean was \$11,587.15 for the non-readmitted group (SD \$5,988.81) compared to \$29,856.02 (SD \$31,976.39; p<0.001). Patients who were readmitted had an incremental mean difference of \$15,781 (95% CI \$15,168 - \$16,394.4; p < 0.001) compared to those who were not readmitted. The aggregate costs of the entire study cohort were \$1.34 billion: \$1.03 billion for the non-readmitted subgroup, \$315 million for the readmitted group (\$144 million during their index admission and \$170 million during their readmission). This aggregate cost was annualized to \$489 million: \$374 for the non-readmitted subgroup, \$114.5 million for the readmitted group (\$52.5 million during their index admission and \$62 million during their readmission).

## **Discussion**

Readmissions have become particularly relevant since the Affordable Care Act mandated the CMS to establish the Hospital Readmission Reduction Program (HRRP) in 2012,<sup>4</sup> which

reduces payments to hospitals with high readmissions with the ultimate goal of improving quality of care. Hospital payments are expected to decrease by \$566M in the fiscal year 2019 due to the HRRP.<sup>16</sup> This has stimulated national efforts to address readmissions, specifically in the bariatric surgery arena, such as the MBSAQIP Decreasing Readmissions through Opportunities Provided (DROP) initiative, which is already showing promising results.<sup>17</sup> The present study provides valuable nationally-representative data that give an important perspective on the scope of readmissions.

This nationwide analysis showed that the readmission rate after bariatric surgery was 10.7% at 180 days. Of these, two-thirds are directly related to the index procedure. Just half of the readmissions are detected using the traditional 30-day readmission rate metric. Over 30% of 180-day readmissions occur to a different hospital than where the surgery took place. Interestingly, over a fifth of readmitted patients required some type of gastrointestinal procedure. The costs associated with readmissions are significant as they more than double of their index admission and represent 13% of the total costs per year associated with bariatric procedures. These findings are important to consider when setting national standards for readmissions after bariatric procedures. These data provide support to the concern that conventional readmission benchmarking fails to capture the true morbidity and healthcare utilization that occurs after discharge of patients who undergo bariatric procedures.

These data are similar with findings from other large cohorts.<sup>5-8,15</sup> Rattan *et al.* found a 4.4% 30-day readmission rate in a large MBSAQIP study.<sup>15</sup> Prior studies examining patients from the NSQIP database found a similar 30-day readmission rate after bariatric surgery (~5%).<sup>3,5,8,18</sup> Although these studies used large cohorts, they did not capture true 30-day readmission rates as readmissions were assessed from day of surgery instead of from the day of

discharge, and they were unable to include readmissions to different hospitals. Other studies using billing data were able to capture true 30-day readmission rates, captured readmissions to different hospitals, and found similar readmission rates (~4-5%) at 30-days.<sup>6,7</sup> Another study found slightly lower 30-day readmission rates (3.8%) using a large all-payer database.<sup>10</sup> However, none of the databases queried in these studies are designed to be representative of the nation as they are large databases with data from institutions across the nation that participate in their program.

Our data also provide useful information on the timing of readmission as we identified a steep increase in readmissions within the first month. Over a fifth of 180-day readmissions occur during the first week of discharge. Additional studies could further characterize readmissions according to their timing to appropriately tailor interventions.

When comparing the three procedures (LGB, LGS and LGBP), we found that the LGBP group had the highest readmission rate. The latter was also independently associated with higher readmissions relative to LGB and LGS, which is comparable to data from the MBSAQIP.<sup>15</sup> Not surprisingly, patients with multiple comorbidities,<sup>19</sup> prolonged length of stay,<sup>15</sup> Medicare or Medicaid insurance<sup>9,10,20,21</sup> and serious adverse events/complications<sup>3,8,15</sup> during the index admission were more likely to be readmitted, which is in line with previous data. In terms of causes for readmission, our findings are also comparable to previous studies that explored this aspect.<sup>3,12,15,20</sup> We found that post-procedure-related complications, postoperative infection, hemorrhage, hematoma or seroma were among the most common for all three procedures. Furthermore, complications of the digestive system (such as nausea, anastomosis stricture, obstruction, ileus) as well as disorders of fluid, electrolyte, and acid-base balance were consistently among the top causes of readmission for all three procedures. Using these data,

clinicians could leverage electronic medical records features to flag populations at risk for readmissions and set up closer follow-up appointments, telehealth appointments, follow-up calls, and outpatient laboratory tests with the intention of capturing predisposing risk factors, symptoms and/or signs that may lead to readmission.

There was significant morbidity associated with these procedures at the time of readmission. We found that a sizable proportion of readmitted patients (~24%) will undergo a gastrointestinal procedure, similar to a prior study that found that around 20% of readmitted patients undergo reoperation within 90-days.<sup>22</sup> As the safety of bariatric procedures continues to improve, it is important to recognize that the reutilization of healthcare and associated morbidity are not insignificant and therefore, it is important to include this information when counseling patients preoperatively.

This study is not without limitations, which are intrinsic to the use of administrative data. These discharge data collected for billing and documentation purposes may lack detailed clinical data, social and family history, laboratory values, pathology reports, radiological findings, functional status, and patient-reported outcomes, or may be subject to coding bias. For instance, there are some ICD-9 diagnosis codes that comprise several post-procedural complications (for instance 997.49 “Other digestive system complications” may capture anastomosis stricture, gastrointestinal complication after surgery, hepatic failure due to a procedure, nausea after surgery, postoperative ileus, postoperative nausea, etc.) and therefore we were unable to discern individual percentage of readmissions attributable to each of those. However, other studies that had more granularity of data described this well<sup>8,12,15,20</sup> and our study serves to provide validity to those findings as we used a nationally-representative cohort where the trend persisted, and we were able to distinguish directly related readmissions using ICD9-CM diagnosis codes and the

framework provided by the MBSAQIP. The retrospective nature of the study makes it subject to misclassification and selection bias. The NRD captures hospitalizations classified as admission and therefore excludes ED visits and patients admitted under observation status, which underestimates the true burden of healthcare utilization and morbidity after discharge. Lastly, some readmissions may be related to socioeconomic circumstances such as not being able to afford prescribed outpatient treatment, imaging or procedures, which these dataset does not allow to control for. Nonetheless, the present study has the largest cohort of bariatric patients published so far, is a nationally-representative cohort of patients undergoing the three most common bariatric procedures in the U.S., includes readmissions to different-than-index-admission hospital and captures readmissions directly related to the bariatric procedure. Furthermore, these analyses support that readmissions are prevalent beyond the 30-day benchmark, as they essentially double by 6 months after discharge.

## **Conclusion**

Readmissions after bariatric surgery continue to occur even 6 months after discharge. Most of them are directly related to the index procedure. Almost a fourth of those readmitted required a procedure and almost a third presented to a different hospital from their initial surgery. They carry a significant burden for the healthcare system and may impair quality of life for patients. Strategies targeted to prevent readmissions beyond the traditional 30-day benchmark may be warranted in this population.



## Tables

**Table 1.** Demographic, clinical and hospital characteristics of patients undergoing bariatric procedures, by readmission status at 180 days. Weighted to represent national estimates

	Non readmitted		Readmitted		<i>p</i>
<b>All Patients, % by row</b>	203501	89.24%	24542	10.76%	
<b>Age, mean (SD)</b>	44.83	12	46.15	12.2	<b>&lt;0.001</b>
<b>Female, % by column</b>	158857	78.06%	19039	77.58%	0.398
<b>Charlson Index, % by column</b>					<b>&lt;0.001</b>
<2	180193	88.55%	19676	80.18%	
>=2	23308	11.45%	4865	19.82%	
<b>Payer, % by column</b>					<b>&lt;0.001</b>
Medicare	32497	15.97%	6839	27.86%	
Medicaid	23719	11.66%	3956	16.12%	
Private insurance	131455	64.60%	12253	49.93%	
Self-pay	7598	3.73%	509	2.07%	
No charge	158	0.08%	15	0.06%	
Other	7880	3.87%	965	3.93%	
Missing	194	0.10%	*	0.02%	
<b>Median household income, % by column</b>					<b>&lt;0.001</b>
0-25th percentile	45446	22.33%	6231	25.39%	
26-50th percentile	50372	24.75%	6319	25.75%	
51th-75th percentile	53974	26.52%	6317	25.74%	
76-100th percentile	50620	24.87%	5303	21.61%	
Missing	3089	1.52%	373	1.52%	
<b>Risk of mortality, % by column</b>					<b>&lt;0.001</b>
Minor likelihood of dying	189917	93.32%	20996	85.55%	
Moderate likelihood of dying	12011	5.90%	2865	11.67%	
Major likelihood of dying	1252	0.62%	515	2.10%	
Extreme likelihood of dying	309	0.15%	164	0.67%	
<b>Severity of illness, % by column</b>					<b>&lt;0.001</b>
Minor loss of function (includes cases with no comorbidity or complications)	122033	59.97%	12358	50.36%	
Moderate loss of function	76276	37.48%	10377	42.28%	
Major loss of function	4687	2.30%	1522	6.20%	
Extreme loss of function	493	0.24%	283	1.15%	
<b>Same state resident, % by column</b>	187268	92.02%	23088	94.08%	<b>&lt;0.001</b>
<b>Type of discharge, % by column</b>					<b>&lt;0.001</b>
Home	199717	98.14%	23220	94.61%	
Short-term hospital	48	0.02%	25	0.10%	
SNF, ICF, Other	317	0.16%	231	0.94%	
Home Health Care	3330	1.64%	1045	4.26%	
Against Medical Advice	85	0.04%	19	0.08%	
<b>Type of hospital (ownership), % by column</b>					0.051
Government, nonfederal	20108	9.88%	2743	11.18%	
Private, not-profit	148238	72.84%	17389	70.86%	
Private, invest-own	35156	17.28%	4410	17.97%	
<b>Teaching status, % by column</b>					0.263
Metropolitan non-teaching	69916	34.36%	8294	33.80%	
Metropolitan teaching	129320	63.55%	15632	63.69%	
Non-metropolitan hospital	4265	2.10%	616	2.51%	
<b>Hospital urban-rural designation, % by column</b>					0.163
Large metropolitan areas with > 1 million residents	131738	64.74%	15590	63.52%	
Small metropolitan areas with < 1 million residents	67498	33.17%	8336	33.97%	
Micropolitan areas	4265	2.10%	616	2.51%	
<b>Hospital bed size, % by column</b>					<b>&lt;0.001</b>
Small	33376	16.40%	3615	14.73%	

Medium	50201	24.67%	5340	21.76%	
Large	119924	58.93%	15587	63.51%	
<b>Hospital volume</b>					0.285
Low volume	45236	22.23%	5636	22.96%	
High volume (>75th percentile)	158266	77.77%	18906	77.04%	
<b>Prolonged length of stay (75th percentile)</b>	33646	16.53%	7772	31.67%	<b>&lt;0.001</b>
<b>Serious adverse event during index admission</b>	3508	1.72%	1220	4.97%	<b>&lt;0.001</b>

\*Cell with count < 10, not shown as per HCUP data user agreement.

**Table 2.** Readmission analyses of patients undergoing bariatric procedures. Weighted to represent national estimates.

<b>Outcome</b>	<b>LGB (n=22945)</b>		<b>LGS (n=82270)</b>		<b>LGBP (n=122829)</b>		<b>Overall (n=228043)</b>		<b>p</b>
<b>30-day readmission analysis</b>									
30-day readmission (overall), n (% of cohort)	882	(3.84%)	3269	(3.97%)	8260	(6.72%)	12411	(5.44%)	<b>&lt;0.001</b>
<b>180-day readmission analysis</b>									
180-day readmission (overall), n (% of cohort)	1906	(8.31%)	6379	(7.75%)	16257	(13.24%)	24542	(10.76%)	<b>&lt;0.001</b>
180-day readmissions directly related to bariatric procedure, n (% of readmissions)	1100	(57.72%)	3969	(62.23%)	10771	(66.26%)	15841	(64.55%)	<b>&lt;0.001</b>
Readmitted to different hospital, n (% of readmissions)	788	(41.36%)	2093	(32.81%)	4765	(29.31%)	7646	(31.16%)	<b>&lt;0.001</b>
Days to readmission, median (IQR)	38	(10-107)	29	(10-93)	29	(9-85)	30	(10-88)	<b>&lt;0.001*</b>
Any GI procedure during readmission, n (% of readmissions)	406	(21.30%)	1174	(18.40%)	4272	(26.28%)	5852	(23.85%)	<b>&lt;0.001</b>
Died during readmission, n (% of readmissions)	0	(0.00%)	30	(0.47%)	87	(0.54%)	118	(0.48%)	0.324

**\*Weighted analysis did not allow median comparison between groups. Unweighted data was analyzed to allow median comparison.**

**Table 3.** Causes of readmission at 180 days, by bariatric procedure

	LGB (N=22945)		LGS (N=82270)		LGBP (N=122829)	
<b>Readmitted, N (%)</b>	1906	(8.31%)	6379	(7.75%)	6379	(13.24%)
<b>Rank</b>	<b>Causes of readmission</b>	<b>(%)</b>	<b>Causes of readmission</b>	<b>(%)</b>	<b>Causes of readmission</b>	<b>(%)</b>
1	Complication of procedure involving implant	(8.03%)	Complication of bariatric procedures	(10.29%)	Complications affecting specified body systems (digestive system complications, respiratory complications, other)	(8.3%)
2	Complications of procedure (postoperative infection; hemorrhage, hematoma or seroma; accidental injury to organ; postoperative shock; postoperative fistula; other)	(5.58%)	Disorders of fluid, electrolyte, and acid-base balance (volume depletion, hyponatremia, hyperpotassemia, fluid overload, hypernatremia, acidosis, alkalosis, not classified)	(8.02%)	S/P Bariatric procedure	(7.3%)
3	S/P Bariatric procedure	(5.58%)	Complications of procedure (postoperative infection; hemorrhage, hematoma, seroma; other; disruption of wound; persistent postoperative fistula; accidental injury to organ; foreign body accidentally left during procedure; unspecified)	(5.05%)	Complications of bariatric procedures	(6.9%)
4	Disorders of fluid, electrolyte, and acid-base balance (volume depletion, hyponatremia, hypopotassemia, acidosis, hyperpotassemia, other)	(5.14%)	Symptoms involving digestive system (Nausea and vomiting, dysphagia, other)	(4.95%)	Disorders of fluid, electrolyte, and acid-base balance (volume depletion, hypopotassemia, fluid overload, acidosis, hyponatremia, hypernatremia, hyperpotassemia, mixed acid-base disorder)	(6.9%)
5	Complications affecting specified body systems (digestive system, cardiac)	(5.11%)	S/P Bariatric procedure	(4.48%)	Complications of procedure (postoperative infection; hemorrhage, hematoma, seroma; accidental injury to organ; other; persistent postoperative fistula; disruption of wound; foreign body accidentally left during procedure; postoperative shock; unspecified)	(6.5%)

**Note:** whenever possible within the diagnosis group, the specific ICD-9 diagnosis codes were investigated and listed under parenthesis in descending order of frequency  
Laparoscopic Gastric Band, LGB; Laparoscopic Gastric Sleeve, LGS; Laparoscopic Gastric Bypass, LGBP

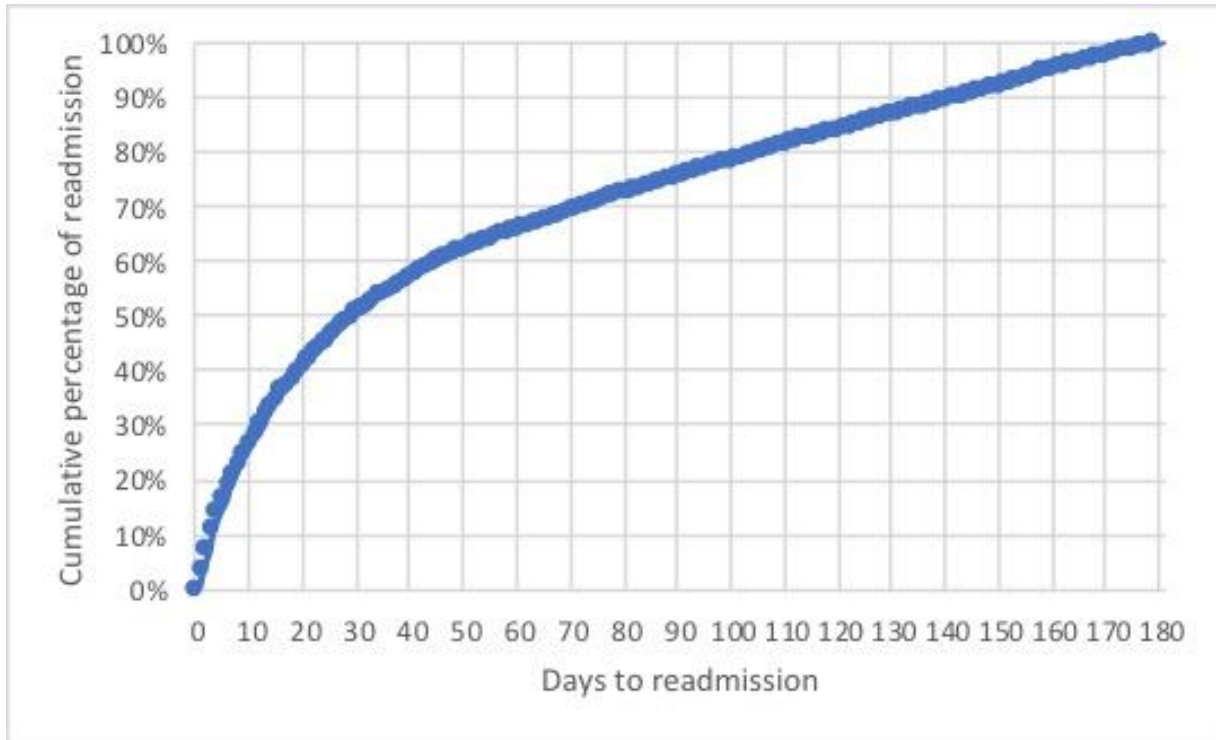
**Table 4. Factors associated with 180-day readmission after bariatric procedures**

	Odds Ratio	95% Confidence Interval	<i>p</i>
<b>Laparoscopic bariatric procedure, % by row</b>			
Laparoscopic band	0.65	(0.58 - 0.73)	<b>&lt;0.001</b>
Laparoscopic gastric sleeve	0.63	(0.59 - 0.67)	<b>&lt;0.001</b>
Laparoscopic gastric bypass	Ref.		
<b>Age, mean (SD)</b>	1.00	(1.00 - 1.00)	0.075
<b>Female, % by column</b>	-	- - -	-
<b>Charlson Index, % by column</b>			
<2	Ref.		
>=2	1.32	(1.22 - 1.43)	<b>&lt;0.001</b>
<b>Payer, % by column</b>			
Medicare	1.86	(1.73 - 1.99)	<b>&lt;0.001</b>
Medicaid	1.61	(1.48 - 1.74)	<b>&lt;0.001</b>
Private insurance	Ref.		
Self-pay	0.81	(0.67 - 0.99)	<b>0.038</b>
No charge	1.19	(0.56 - 2.53)	0.647
Other	1.21	(1.05 - 1.39)	<b>0.008</b>
<b>Median household income, % by column</b>			
0-25th percentile	Ref.		
26-50th percentile	1.01	(0.93 - 1.09)	0.897
51th-75th percentile	1.00	(0.92 - 1.09)	0.985
76-100th percentile	0.98	(0.90 - 1.06)	0.649
Missing			
<b>Risk of mortality, % by column</b>			
Minor likelihood of dying	Ref.		
Moderate likelihood of dying	1.24	(1.10 - 1.39)	<b>&lt;0.001</b>
Major likelihood of dying	1.11	(0.86 - 1.42)	0.435
Extreme likelihood of dying	0.91	(0.49 - 1.69)	0.761
<b>Severity of illness, % by column</b>			
Minor loss of function (includes cases with no comorbidity or complications)	Ref.		
Moderate loss of function	1.09	(1.03 - 1.15)	<b>0.004</b>
Major loss of function	1.34	(1.14 - 1.57)	<b>&lt;0.001</b>
Extreme loss of function	1.58	(0.88 - 2.83)	0.124
<b>Same state resident, % by column</b>			
Yes	Ref.		
No	1.47	(1.30 - 1.67)	<b>&lt;0.001</b>
<b>Type of discharge, % by column</b>			
Home	Ref.		
Short-term hospital	2.82	(1.32 - 6.03)	<b>0.007</b>
SNF, ICF, Other	2.32	(1.59 - 3.39)	<b>&lt;0.001</b>
Home Health Care	1.69	(1.45 - 1.96)	<b>&lt;0.001</b>

Against Medical Advice	1.08	(0.46	-	2.49)	0.865
<b>Type of hospital (ownership), % by column</b>					
Government, nonfederal	1.03	(0.92	-	1.15)	0.625
Private, not-profit	Ref.				
Private, invest-own	1.15	(1.05	-	1.26)	<b>0.003</b>
<b>Teaching status, % by column</b>					
Metropolitan non-teaching	-	-	-	-	-
Metropolitan teaching	-	-	-	-	-
Non-metropolitan hospital	-	-	-	-	-
<b>Hospital urban-rural designation, % by column</b>					
Large metrop areas with > 1 million resid	Ref.				
Small metrop areas with < 1 million resid	0.96	(0.90	-	0.96)	0.899
Micropolitan areas	1.13	(0.92	-	1.13)	0.92
<b>Hospital bed size, % by column</b>					
Small	0.89	(0.81	-	0.99)	<b>0.027</b>
Medium	0.88	(0.82	-	0.94)	<b>&lt;0.001</b>
Large	Ref.				
<b>Hospital volume</b>					
Low volume	-	-	-	-	-
High volume (>75th percentile)	-	-	-	-	-
<b>Prolonged length of stay (&gt;75th)</b>	1.80	(1.70	-	1.91)	<b>&lt;0.001</b>
<b>Serious adverse event during index admission</b>	1.20	(1.02	-	1.42)	<b>0.024</b>

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**Figure.** Cumulative percentage of readmissions after bariatric procedure up to 180 days.



## Appendix. Readmission diagnoses classified as related to index procedure

Berger et al.'s reasons for readmission listed as "likely related" to index procedure - MBSAQIP Data Registry	ICD9-CM Diagnosis code(s)	ICD9-CM Diagnosis code description
Abdominal Pain, Not Otherwise Specified	789	Abdominal pain
	787	Symptoms involving digestive system (includes nausea, vomiting, heartburn, dysphagia, flatulence, eructation, gas pain, visible peristalsis, abnormal bowel sounds, incontinence of feces, abnormal feces, diarrhea, other)
Anastomotic Ulcer	534	Gastrojejunal ulcer
Anastomotic/Staple Line Leak	537.9	Unspecified disorder of stomach and duodenum
	537	Other disorders of stomach and duodenum
Band Erosion	539	Complications of bariatric procedures
Band Slippage/Prolapse	539	Complications of bariatric procedures
Bile Reflux Gastritis	535	Gastritis and duodenitis
	536	Disorders of function of stomach
Bleeding	998	Other complications of procedures not elsewhere classified
GI Perforation	531	Gastric ulcer (includes with and without perforation)
Gallstone Disease	574	Cholelithiasis
	575	Other disorders of gallbladder
	576	Other disorders of biliary tract
Gastric Distention	536	Disorders of function of stomach
Gastro-Gastric Fistula	998	Other complications of procedures not elsewhere classified
	564.2	Postgastric surgery syndromes
Incisional Hernia	551.2	Ventral hernia with gangrene
	552.2	Ventral hernia with obstruction
	553.2	Ventral hernia without mention of obstruction or gangrene
Infection/Fever	780.6	Fever and other physiologic disturbances of temperature regulation
	998.5	Postoperative infection not elsewhere classified
	996.6	Infection and inflammatory reaction due to internal prosthetic device implant and graft
	998.02	Postoperative shock, septic
	038	Septicemia
	785.52	Septic shock
	567	Peritonitis and retroperitoneal infections
	995.9	Systemic inflammatory response syndrome (sirs)
567.22	Peritoneal abscess	
Internal Hernia	551.8	Hernia of other specified sites, with gangrene
	552.8	Hernia of other specified sites, with obstruction
	553.8	Hernia of other specified sites, without obstruction
Intestinal Obstruction	560	Intestinal obstruction without mention of hernia
LAGB - Port, Tubing or Band Problem	539	Complications of bariatric procedures
Nausea and Vomiting, Fluid, Electrolyte, or Nutritional Depletion	787	Symptoms involving digestive system (includes nausea, vomiting, heartburn, dysphagia, flatulence, eructation, gas pain, visible peristalsis,

		abnormal bowel sounds, incontinence of feces, abnormal feces, diarrhea, other)
Other	999	Complications of medical care not elsewhere classified
Other Abdominal Sepsis		See Infection/Fever
Other Respiratory Failure	518.81	Acute respiratory failure
	518.5	Pulmonary insufficiency following trauma and surgery
Pneumonia	480-488	Pneumonia and Influenza
Pulmonary Embolism	415.1	Pulmonary embolism and infarction
Strictures/Stomal Obstruction	997.49	Other digestive system complications
	996.1	Mechanical complication of other vascular device, implant, and graft
Vein Thrombosis Requiring Therapy	453	Other venous embolism and thrombosis
	452	Portal vein thrombosis
Wound Infection/Evisceration	998.59	Other postoperative infection
	998.31	Disruption of internal operation (surgical) wound

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