



Impact of the COVID-19 Pandemic on Inpatient and Outpatient Utilization of Bariatric Surgery

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Received: 2 May 2022 / Accepted: 13 September 2022

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Abstract

Background During the COVID-19 pandemic, deferral of inpatient elective surgical procedures served as a primary mechanism to increase surge inpatient capacity. Given the benefit of bariatric surgery on treating obesity and associated comorbidities, decreased access to bariatric surgery may have long-term public health consequences. Understanding the extent of the disruption of the COVID-19 pandemic to bariatric surgery will help health systems plan for appropriate access.

Materials and methods This is an observational cohort study using the PINC AI Healthcare Database from 1/1/2019–6/31/2021. A Poisson regression model with patient characteristics and hospital-fixed effects was used to assess the relative monthly within-hospital reduction in surgical encounters, variations by race and ethnicity, and shift from inpatient to outpatient procedures. A multivariate linear probability model was used to assess the change in 30-day readmissions from 2020 and 2021 compared to 2019.

Results Among 309 hospitals, there were 46,539 bariatric procedures conducted in 2019 with a 14.8% reduction in volume to 39,641 procedures in 2020. There were 22,642 bariatric procedures observed from January to June of 2021. The most pronounced decrease in volume occurred in April with an 89.7% relative reduction from 2019. Black and Hispanic patients were more likely to receive bariatric surgery after the height of the pandemic compared to white patients. A clinically significant shift from inpatient to outpatient bariatric surgical procedures was not observed. Relative to 2019, there were no significant differences in bariatric surgical readmission rates.

Conclusion During the pandemic there was a sizable decrease in bariatric surgical volume. There did not appear to be disparities in access to bariatric surgery for minority patients. We did not observe a meaningful shift toward outpatient bariatric surgical procedures. Post-pandemic, monitoring is needed to assess if hospitals have been able to meet the demand for bariatric surgical procedures.

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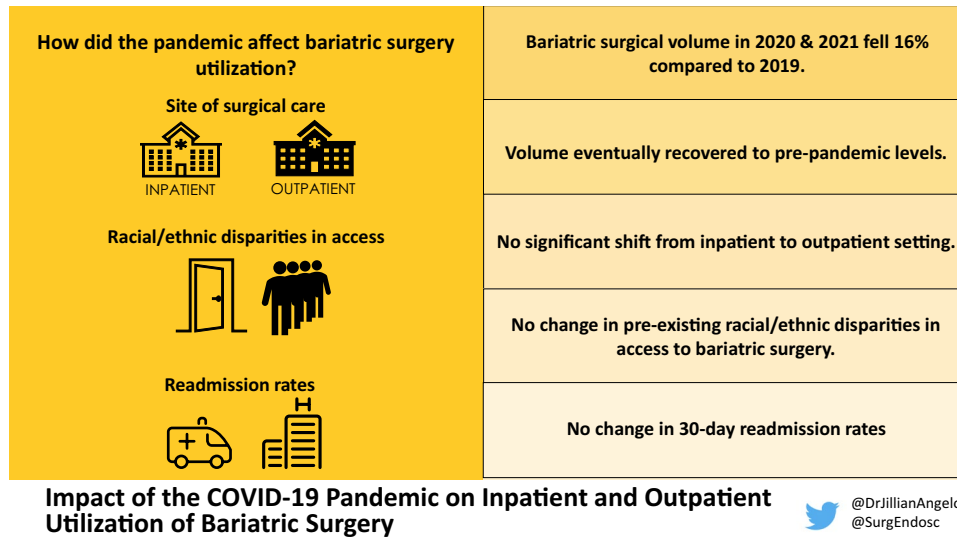
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Graphical abstract



Keywords Bariatric surgery · Utilization · COVID-19 · Volume · Readmission · Race

COVID-19 has posed an unprecedented shock to the healthcare system. In order to both decrease the burden on the healthcare systems in the setting of the pandemic and because of the increased risk of severe COVID infections in obese individuals, the volume of bariatric surgery was severely curtailed in response to the pandemic [1–3]. Because bariatric surgery has been considered an elective inpatient operation by most health systems, patients being evaluated for bariatric surgical procedures may have potentially borne the burden of state-mandated bans on inpatient elective surgical procedures. Assessments of the impact of the COVID-19 pandemic on bariatric surgery has so far primarily focused on single-institution series or surveys of surgeons [4, 5]. Therefore, national data from a representative set of US hospitals would provide timely and important data on the extent to which the COVID-19 pandemic may have reduced access to bariatric surgery.

The COVID-19 pandemic also disproportionately affected Black and Hispanic individuals over a broad range of geographic areas. There was a higher rate of cases among Black patients and higher mortality rates in Black patients and Hispanic patients compared to White patients [6–9]. As obesity is a known risk factor for severe COVID-19 disease, these populations are particularly vulnerable to reduced access to bariatric surgery.

In order to provide an empirical analysis of the consequences of the COVID-19 pandemic on access to bariatric surgery, we used a national dataset of hospital discharges to assess changes in bariatric surgical utilization from 2019 to 2021. We first assessed the changes in trends in bariatric

surgical utilization and whether the bed capacity constraints during the pandemic prompted a shift from inpatient to outpatient bariatric surgery. Second, we assessed if bariatric surgical utilization varied by race and ethnicity during the pandemic. Third, we assessed if readmissions rates were higher during the pandemic following bariatric surgery.

Materials and methods

Data

We analyzed the PINC AI Healthcare Database (PHD), a national, all-payer, geographically diverse de-identified hospital administrative database. We identified 309 hospitals performing bariatric surgery with continuous monthly data submissions from January 1, 2019 to June 30th, 2021. The hospitals in the PHD are broadly representative of acute care hospitals in the US (Supplemental Table I).

Variables

The primary outcome of this study was the within-hospital rate ratio of bariatric surgical encounters in 2021 and 2020 relative to 2019. Data was gathered for the two most commonly performed bariatric procedures including sleeve gastrectomy and Roux-en-Y gastric bypass using the International Classification of Disease, Tenth Revision, Clinical Modifications (ICD-10-CM) procedure codes and current procedural terminology (CPT). We assessed the relative

change in bariatric surgical encounters varied by race and ethnicity and by inpatient and outpatient status.

The secondary outcome was the odds of any-cause 30-day readmission after the index procedure. Planned readmissions (such as organ transplants) were excluded.

Patient variables included age, race and ethnicity (categorized as non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Asian, and Other), gender, insurance status, procedure, coexisting condition, and BMI. Mean imputation was used for missing data. Hospital-level variables included size, teaching status, region, and geographic status (rural, urban).

Analyses

We first used a Poisson model to assess the rate ratio (RR) of encounters by hospital by month for calendar years 2020 and 2021 versus 2019. The Poisson model was chosen to accommodate the skewed distribution of admissions and estimation of the relative change in admissions instead of the absolute difference. We chose the rate ratio as our main outcome to generalize our findings across varying hospital sizes and admissions in our sample. We used a hospital-fixed effects approach to allow each hospital to serve as its own control. This approach adjusts for all time invariant hospital-level covariates and allows for within-hospital comparisons of changes in overall surgical encounters. Overall bariatric surgical volume was then stratified by inpatient and outpatient status. To assess for disparities in the change in bariatric utilization during 2020 and 2021 compared to 2019, we repeated the same analytic approach with a stratification by race and ethnicity.

Lastly, we compared changes in adjusted monthly 30-day readmission risks using a patient-level multivariable linear probability model controlling for patient, procedure, and facility-level characteristics. Again, the model included fixed effects for facilities, months, and years, so that readmissions were compared within the same facilities for the same months.

All analyses were conducted in STATA/MP (Version 16.1) with two-tailed t-tests, where applicable, and a p value of 0.05 to establish statistical significance. Robust 95% confidence intervals were calculated for all analyses.

Sensitivity analyses

We performed a sensitivity analysis looking at the change in bariatric surgery volume in outpatient facilities. To do so, we replicated our original modeling approach on the subset of patients that underwent surgery in outpatient settings.

(Supplemental Figure I) We also performed sensitivity analyses to assess the robustness of our Poisson model results. We repeated our modeling approach but with a facility-fixed effects linear model. (Supplemental Figure II).

Results

Patient and hospital characteristics

Data was available on 46,539 patients in 2019, on 39,641 patients in 2020, and for 22,642 patients in 2021. The population during the pandemic years had small but statistically significant shifts toward a younger population (proportion of 19–49 year old's, 69.55% in 2021 vs 64.85% in 2019, $p < 0.001$, Table 1). There was a shift away from White and Asian patients to a greater proportion of Black (21.73% in 2021 vs 17.66% in 2019, $p < 0.001$) and Hispanic patients (13.16% in 2021 vs 10.96% 2019, $p < 0.001$).

Bariatric surgical procedures 2020–June 2021 vs 2019

In 2019 there were 46,539 bariatric procedures conducted in our sample which fell to 39,641 procedures in 2020. In 2020, there was a 13.7% (95% CI 10.7%–16.6%) reduction in volume compared to 2019 (Supplemental Table II). There was a pronounced reduction in April and May 2020 where the relative change from 2019 was – 89.7% and – 54.6%, respectively (April 2020: 95% CI – 91.0% to – 88.2%; May 2020: 95% CI – 60.5% to – 47.8%). Another more modest decline in bariatric procedures was seen in November 2020 through January of 2021 coinciding with the third wave of the pandemic (November 2020: – 6.0% 95% CI – 11.8% to 0.2%; December 2020: – 13.3% 95% CI – 20.6% to – 5.4%; January 2021: – 19.1% 95% CI – 27.4% to – 9.8%) (Fig. 1).

From January 2021 to June 2021, we observed 22,642 bariatric procedures in our sample. Compared to the same time frame in 2019, bariatric surgical volume rose by 11.1% (95% CI 4.2%–18.4%) in 2021 (Supplemental Table II). The relative reduction in January 2021 compared to 2016 was 19.1% (95% CI 9.8%–27.4%). In February 2021, volume of bariatric procedures was almost equal to that of 2019 levels. In subsequent months there were relative increases in surgical volume relative to 2019 of escalating magnitude. The largest relative increase occurred in April 2021 where bariatric surgical volume was 17.5% more than it was in April of 2019 (17.5% increase, 95% CI 9.8%–25.7%).

Similar trends were observed in the absolute change in procedural volume (Supplemental Figure II).

Table 1 Patient characteristics undergoing bariatric surgery, 2019–2021

	2019	2020	2021 (January–June)	<i>P</i> value ^a : 2020 vs 2019	<i>p</i> value ^a : 2021 vs 2019
<i>N</i>	46,539	39,641	22,642		
Age				< 0.001	< 0.001
≤ 18 years	0.41%	0.38%	0.51%		
19–49 years	64.85%	67.14%	69.55%		
50–64 years	28.14%	26.43%	25.01%		
≥ 65 years	6.61%	6.05%	4.93%		
Sex				< 0.001	< 0.001
Male	80.39%	81.91%	82.66%		
Female	19.61%	18.09%	17.34%		
Unknown	0.00%	0.00%	0.01%		
Race				< 0.001	< 0.001
NH White	60.24%	59.70%	57.16%		
NH Black	17.66%	18.78%	21.73%		
Hispanic	10.96%	11.39%	13.16%		
NH Asian	11.14%	10.13%	4.03%		
Other	0.00%	0.00%	3.92%		
Insurance				< 0.001	< 0.001
Medicare	14.50%	13.24%	11.53%		
Medicaid	20.42%	22.10%	25.00%		
Commercial/managed care	57.17%	56.33%	54.68%		
Self-pay	2.52%	2.72%	2.99%		
Other	5.39%	5.61%	5.79%		
Coexisting condition ^b				0.59	0.08
Congestive heart failure	2.33%	2.36%	2.08%		
Chronis obstructive pulmonary disease	20.17%	19.69%	20.51%		
Hypertension	54.24%	52.71%	51.29%		
Diabetes mellitus	28.42%	26.95%	25.05%		
Renal failure	2.65%	2.76%	2.56%		
Obesity	95.78%	95.63%	95.99%		
Depression	20.97%	21.02%	21.93%		
Procedure				< 0.001	< 0.001
Sleeve gastrectomy	70.28%	67.84%	68.53%		
Gastric bypass	29.73%	32.17%	31.48%		
Clinical values					
% Missing BMI	1	1	1	< 0.001	< 0.001
BMI, mean (SD)	47.58 (13.57)	47.6 (14.04)	48.37 (14.75)	0.94	< 0.01

^a*p* value obtained from logistic regressions with an indicator for category as the dependent variable and an indicator for year as the independent variable with robust standard errors adjusted for clustering within hospitals

^bElixhauser comorbidity categories were modified to include primary diagnoses, in addition to secondary diagnoses. Elixhauser scores represent unweighted Elixhauser comorbidity sums (1 point per comorbidity)

Patient characteristics from 2019 through June 2021 with *p* values to assess for significant differences between 2020 vs 2019, and 2021 vs 2019

Distribution of Inpatient and Outpatient Bariatric Surgical Procedures

The distribution of bariatric surgeries performed across inpatient and outpatient settings remained relatively constant outside of the large reduction in volume around April

of 2020. In April 2020, there were 16 inpatient sleeve gastrectomy and 79 inpatient gastric bypass procedures. After inpatient procedural volume rebounded in June 2020, monthly volume ranged from 1709 to 2784 procedures for inpatient sleeve gastrectomies and 828 to 1393 procedures for inpatient gastric bypass procedures (Fig. 2). After June

Fig. 1 Relative change in bariatric surgical procedures, 2020–2021 vs 2019. Results from a multivariate linear regression with facility-fixed effects conducted at the patient-level and controlling for patient and procedures characteristics

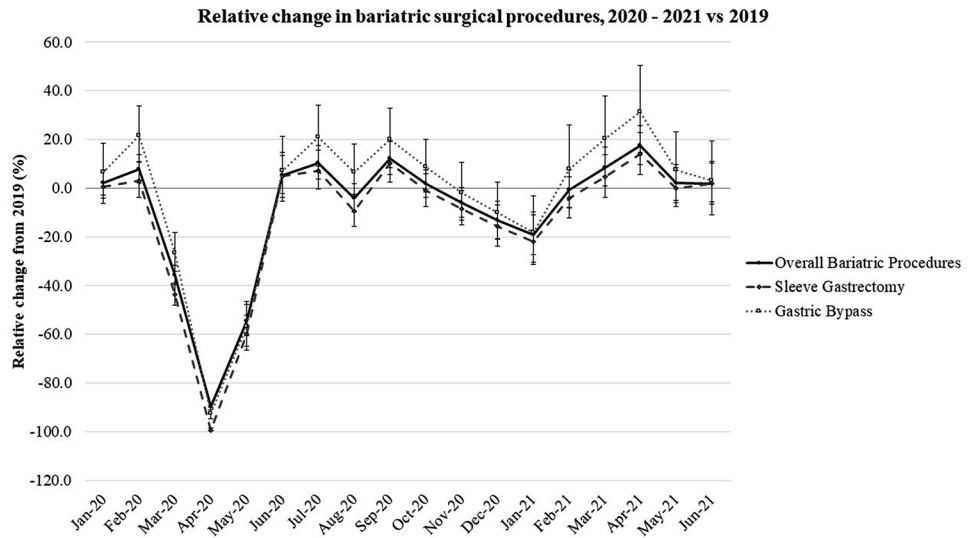
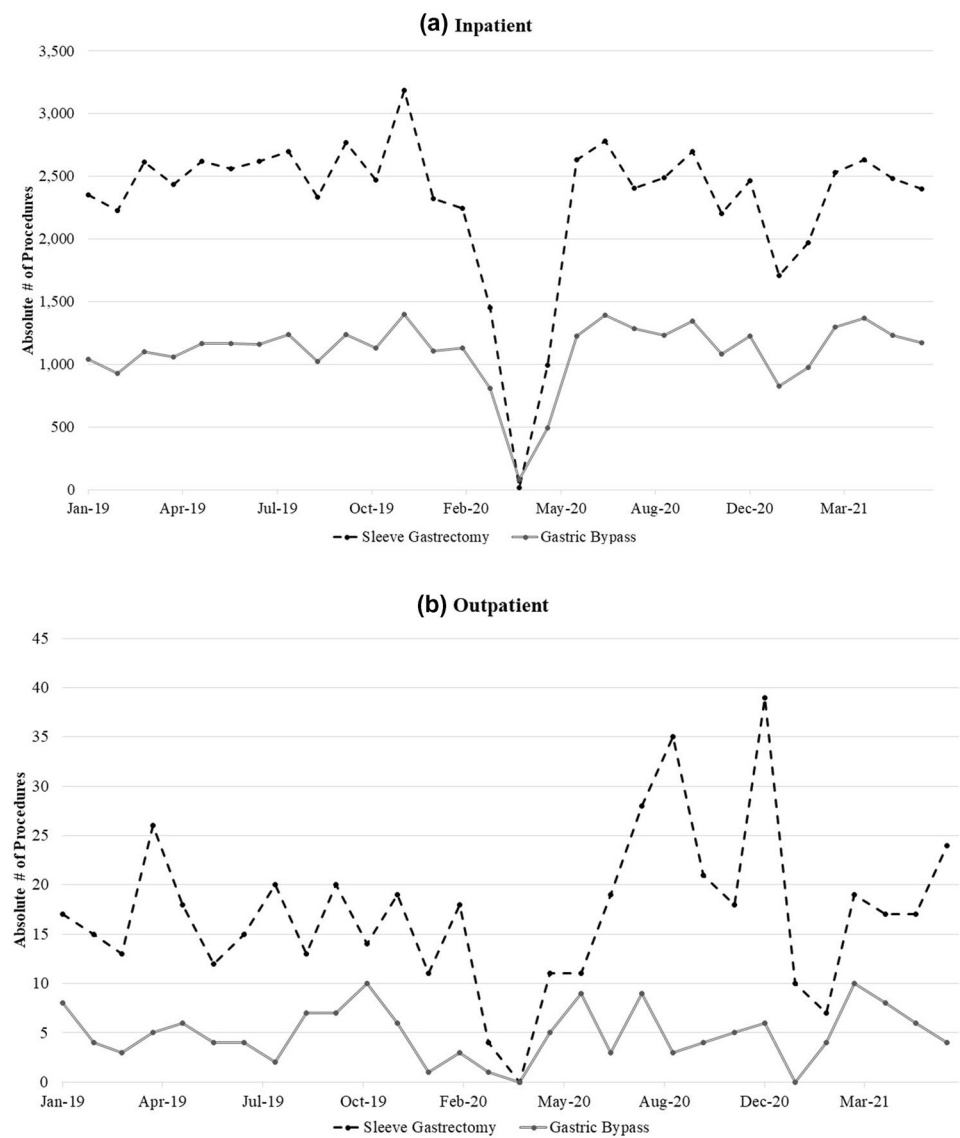


Fig. 2 Absolute Number of Monthly Bariatric Procedures, 2019–2021. Results from a Poisson model with hospital-fixed effects was used to assess the relative monthly within-hospital reduction in bariatric surgical encounters in 2020 and 2021 compared to 2019



2020, outpatient procedural volume ranged from 184 to 434 procedures for outpatient sleeve gastrectomies and 28 to 56 procedures for outpatient gastric bypass surgeries. We did not observe a significant shift from inpatient to outpatient bariatric surgical procedures (Fig. 1a, b and Supplemental Figures I and II).

Racial disparities in bariatric surgical procedures

In 2020 relative to 2019, all races and ethnicities experienced a relative decrease in bariatric procedural volume (Black: -9.4% , 95% CI -14.9% to -3.7% ; Hispanic -11.5% , 95% CI -21.5% to -0.2% ; White -15.6% , 95% CI -19.0% to -12.0%). In 2021 relative to 2019, only Black and Hispanic patients, respectively, experienced a statistically significant relative increase in bariatric surgical volume of 40.0% (95% CI 23.4% – 59.0%) and 38.1% (95% CI 3.6% – 84.1%) (Fig. 3 and Supplemental Table II). Black patients experienced a relative change in bariatric procedures in 2020 and 2021, respectively, that was 8.4% (95% CI 4.1% – 13.0%) and 21.8% (95% CI 12.7% – 31.7%) larger than that of White patients. Utilization of bariatric procedures among Hispanic patients was similarly significantly different from that of White patients in 2020 where the relative change in procedural volume was 8.2% (95% CI 0.2% – 17.0%) higher than that among White patients (Supplemental Table III).

Change in Risk-Adjusted 30-day Readmission Rates

There were no statistical differences in yearly risk-adjusted 30-day readmission rates in 2020 and 2021 relative to (2020: 0.1% , 95% CI -0.2% to $+0.3\%$; 2021: -0.1% , 95% CI -0.4% to $+0.3\%$) (Table 2). A notable monthly outlier is the 13.4% (95% CI, 5.5% – 21.2%) readmission rate in April 2020, during which only 95 procedures were performed

as this occurred during the peak of the initial pandemic lockdown.

Discussion

Bariatric surgery volume decreased by 14.8% in 2020 compared to 2019. Although we hypothesized decreased access for racial and ethnic minorities, we instead found that Black and Hispanic patients experienced a higher relative rate of utilization of bariatric procedures during the pandemic compared to White patients. Overall, we did not find worse outcomes of bariatric surgical procedures in the form of increased risk-adjusted 30-day readmission rates during the pandemic. Taken together, our findings should assure surgeons and health system leaders that despite the extraordinary shocks to the health care system, trends in bariatric surgical care during the COVID-19 pandemic were relatively consistent with pre-pandemic trends. Monthly procedural volume recovered to pre-pandemic levels, distribution of site of care and readmission rates remained relatively stable, and existing racial/ethnic disparities in access to care did not widen.

During the COVID-19 pandemic, there was a significantly decrease in utilization of bariatric surgery with a decline of 16% from 2019 to 2020 and the early part of 2021. Prior studies have reported a decline in inpatient and outpatient surgical encounters of 13% and in inpatient gastrointestinal surgery of 24% – 98% in 2020 compared to 2019 [10, 11]. While there was a return to baseline operative volume in July and September of 2020, a full consistent return to “normal” was not seen until March 2021, nearly two years after the start of the pandemic indicating prolonged consequences on the healthcare system and on patients awaiting bariatric surgery.

Fig. 3 Relative change in bariatric surgical procedures by race and ethnicity, 2020–2021 vs 2019. Results from a Poisson model with hospital-fixed effects stratified by race and ethnicity was used to assess the relative monthly within-hospital reduction in bariatric surgical encounters in 2020 and 2021 compared to 2019

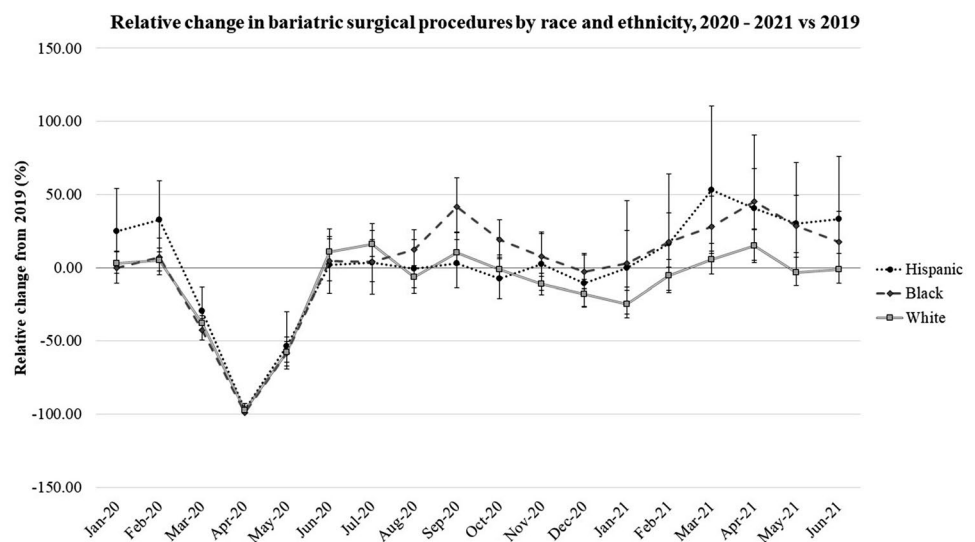


Table 2 Risk-adjusted 30-day readmission rates 2020 through June 2021

	Total procedures	Change relative to 2019 (%)	Lower CI (%)	Upper CI (%)	<i>p</i> value
Jan-20	3594	- 0.3	- 1.1	0.4	0.42
Feb-20	3541	0.6	- 0.2	1.4	0.13
Mar-20	2357	- 0.2	- 1.2	0.7	0.60
Apr-20	95	13.4	5.5	21.2	<0.001
May-20	1629	- 0.1	- 1.2	1.0	0.91
Jun-20	4080	0.0	- 0.8	0.8	0.97
Jul-20	4394	- 0.1	- 0.8	0.6	0.78
Aug-20	3933	1.1	0.3	2.0	0.01
Sep-20	3984	0.2	- 0.6	1.0	0.64
Oct-20	4315	0.0	- 0.7	0.8	0.99
Nov-20	3534	- 0.7	- 1.4	0.0	0.04
Dec-20	4185	- 0.2	- 0.8	0.5	0.65
Jan-21	2788	0.4	- 0.5	1.2	0.42
Feb-21	3241	1.1	0.2	2.0	0.02
Mar-21	4212	- 0.2	- 0.9	0.5	0.55
Apr-21	4366	0.0	- 0.9	0.9	0.99
May-21	4060	- 0.7	- 1.5	0.1	0.10
Jun-21	3975	- 0.5	- 1.5	0.4	0.25
Overall 2020	39,641	0.1	- 0.2	0.3	0.57
Overall 2021	22,642	- 0.1	- 0.4	0.3	0.77

Results from a multivariate linear regression with facility-fixed effects conducted at the patient-level and controlling for patient and procedures characteristics

Delaying bariatric surgery could have untoward consequences of progression of disease for obese individuals [12]. While the effect of the pandemic on the burden of obesity and its related comorbidities cannot yet be fully assessed, preliminary studies have been emerging with concerning findings. In a large study in Europe, body weight was found to increase in 55% of patients mainly due to lower rates of physical activity and poor eating habits [12]. In self reported studies, patients from obesity medicine clinics and bariatric surgery practices endorsed worsening anxiety, depression, more difficulty achieving weight loss goals, less exercise time and intensity, stock-piling of food, increased snacking, and stress eating [13–15]. All of these findings and behaviors are associated with weight gain. Therefore the need for bariatric surgery will become all the greater as we emerge from the height of the pandemic. This is particularly true considering the time-sensitive burden of diabetes in obese individuals, which has been shown through multiple randomized controlled trials to be significantly alleviated with bariatric surgery [16]. Given the severe and progressive nature of obesity, consideration should be made on whether bariatric surgery should be considered “elective” or instead as vital and necessary surgical metabolic procedures to reduce cardiovascular risk and improve overall health. Redefining bariatric surgical procedures as necessary and non-elective

may potentially mitigate the effect of future pandemics on reducing access to an important treatment for obesity and related disorders.

It is well known obesity is a major risk factor for severe COVID-19 infection [17]. Recent data suggests that patients who have undergone bariatric surgery have less severe COVID-19 infections when matched against those who have not undergone bariatric surgery. Amininan et al. reported a 60% lower risk of severe COVID after metabolic surgery [18]. Obesity related medical comorbidities also place the patients at higher risk for more severe disease, particularly diabetes [1, 17]. This might suggest that bariatric surgery adds a protective factor against severe COVID-19 infection [18], and moving forward, surgeons and health system leaders should support greater efforts to increase accessibility for obese patients to undergo surgical intervention in a potentially endemic COVID-19 landscape.

As health systems confront the pent-up demand for previously postponed bariatric surgical procedures, protocols should be in place to ensure equitable criteria for prioritization of surgical cases. Given the need to ensure efficient surgical care delivery, it is important for surgeons to optimize patient selection, implement bariatric enhanced recovery after surgery protocols, and maximize postoperative day one discharges [4]. The Diabetes Surgery Summit has recommended developing criteria to prioritize

bariatric surgery for certain higher-risk patients including prioritization for patients with a greater burden of medical co-morbidities over a first come, first serve basis [19]. These include expediting access to care for patients with moderate to advanced diabetes, those awaiting time-sensitive treatment such as organ transplants or hip replacements, those with BMI > 60, > 2 metabolic conditions other than type I DM, obesity hypoventilation syndrome, severe OSA, heart failure class III and above, and chronic stage 3–4 kidney disease [17, 19].

One important finding of our study is that despite the emphasis on decreasing inpatient bed utilization in US hospitals during the pandemic, we did not find a meaningful shift from inpatient to outpatient surgical procedures. There was an increase in outpatient bariatric procedures in 2021, especially sleeve gastrectomy procedures, but no accompanying drop in inpatient procedures. There has been an overall trend in bariatric surgery to transition to the outpatient setting, with results suggesting comparable outcomes such as leak rate, bleeding, re-operation and mortality with inpatient bariatric surgical procedures [20–22]. We had hypothesized that due to bed shortages and state-mandated inpatient elective surgery deferrals, the trend would shift toward outpatient bariatric procedures. Additionally, many insurance companies around the country have shifted coverage determinations to only allow for outpatient bariatric surgical procedures in an effort to minimize costs. Our findings suggesting stable and low volumes of outpatient bariatric surgical procedures suggests that widespread insurance denials of inpatient bariatric surgical coverage would be detrimental to patient access as the overwhelming majority of bariatric surgical procedures remain in the inpatient setting. Alternative solutions to maximize inpatient bed capacity while maintaining appropriate postoperative monitoring and care of patients may need to instead rely on acute hospital care at home (“home hospital”) programs [23].

We did not find significant disparities in access to bariatric surgical patients for minority patients; instead, we actually found that Black and Hispanic patients had relatively higher rates of utilization of bariatric surgical procedures than White patients. Prior studies have suggested that racial minorities utilized bariatric surgery less than White patients despite the high prevalence of obesity and obesity related comorbidities [24, 25]. Our finding of a significantly greater rate of bariatric surgery in Black and Hispanic populations vs White populations after the hospitals re-opened may be due to several factors. First, the higher rate of medical comorbidities in minority patients may reflect the prioritization of bariatric care on a need-basis over the “first come first serve.” Alternatively, White patients may be more preference sensitive in terms of undergoing bariatric surgical procedures and may have elected to delay procedures until after the pandemic. This

is consistent with prior studies showing greater decrease in utilization of elective surgical procedures by White patients during the pandemic [10]. Continued research is needed to monitor access to care as hospitals address the backlog of bariatric surgical procedures.

There are several limitations to this study. The PHD is dependent on hospital reporting, and variables such as race and ethnicity are dependent on accuracy in reporting by the hospitals. As PHD is also a hospital-based dataset, our estimates of changes in bariatric surgical volume may not capture those procedures in non-hospital affiliated ambulatory surgical centers. Therefore, our estimates of outpatient procedures may be an underestimate.

The COVID-19 had significant effects on utilization of bariatric surgery, with a 16% decrease in overall volume. Instead of racial disparities in access to bariatric surgical procedures, we instead find increased relative utilization of bariatric surgical procedures by Black and Hispanic patients during the pandemic. There were no statistical differences in risk-adjusted 30-day readmission rates compared to 2019. Our findings suggest that there may be significant unmet demand for bariatric surgical procedures that were deferred during the pandemic. Despite the pressures to shift toward outpatient procedures, there has not yet been a significant shift toward outpatient bariatric surgical procedures among US hospitals. Ongoing monitoring is needed to ensure safe and equitable access to bariatric surgical procedures in the post-pandemic era.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00464-022-09655-3>.

Disclaimer The views expressed in the manuscript are those of the authors and do not express the views of Harvard University.

Author contributions Dr. Jillian Angelo had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Funding This project was supported by a research grant from The Commonwealth Fund.

Declarations

Disclosures This manuscript was written and submitted for publication prior to the authors’ government service. Any views or opinions expressed are those of those authors and are not on behalf of the federal government. Dr. Thomas Tsai reported grants from the Massachusetts Consortium on Pathogen Readiness underwritten by the Massachusetts Life Sciences Center, the William F. Milton Fund of Harvard University, and Arnold Ventures. Drs. Jillian Angelo, David Spector, John Orav, and Ali Tavakkoli have no conflicts of interest or financial ties to disclose. Mark Soto and Dannie Dai have no conflicts of interest or financial ties to disclose.

Role of the funder/sponsor The funding organizations had no role in the design and conduct of the study; collection, management, analysis,

and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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