Impact of the COVID-19 Pandemic on Metabolic and Bariatric Surgery Utilization and Safety in the United States

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Received: 19 January 2022 / Revised: 15 April 2022 / Accepted: 20 April 2022 / Published online: 2 May 2022
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Abstract
Background Metabolic and bariatric surgery (MBS) is a safe and effective treatment option for severe obesity. The utilization and health and safety outcomes of MBS in the United States (US) during the COVID-19 pandemic versus 2015–2019 among adolescent and adult populations and by ethnic group is largely unknown.

Methods The 2015–2020 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) longitudinal (30-day) cohort data was used to compare adolescent and adult (N = 1,134,522) post-operative outcomes and to calculate MBS utilization pre-pandemic (2015–2019) versus pandemic (2020). Cochran-Armitage trend tests compared MBS utilization and safety outcomes over time from 2015 to 2020. Logistic regression analysis compared the odds of hospital readmission and MBS completion pre-pandemic versus pandemic by key characteristics.

Results MBS utilization increased by 8.1% among youth (from 970 to 1140 procedures) and decreased by 10.2% among adults (from 205,232 to 167,384) from 2019 to 2020, respectively. MBS significantly increased by 18.5% during the pandemic for youth who identified as other/multi-race ethnicity (P trend < 0.001). Among US youth, the number of reoperations and reinterventions significantly decreased over the 6-year time frame (P trend < 0.001). Among US adults, 30-day post MBS mortality, reoperations, readmissions, and reinterventions all showed a significant decrease over time (P trend < 0.001) while septic shock and sepsis increased from pre-pandemic to the first year of the pandemic (P trend < 0.001).

Conclusion In comparison to 2019 (or to previous years), US MBS utilization increased for youth but decreased for adults during the first year of the COVID-19 pandemic. Safety outcomes were comparable to those of the pre-pandemic years.

Keywords Bariatric surgery · Utilization · Safety · COVID-19 · United States
Simultaneously, there have been several reports of rates of obesity increasing for both pediatric [7, 8] and adult populations during the pandemic [9, 10]. Moreover, reports show that compared to those with healthy weight before the pandemic, those with obesity showed significantly higher increases in body mass index (BMI) during the pandemic [8]. As we enter a new wave of the protracted COVID-19 pandemic, these findings highlight the need for evidence-based treatments to address the worsening obesity epidemic.

MBS continues to remain a popular adult elective procedure in the US with about a quarter of a million patients undergoing the procedure annually [11] as it is safe and efficacious in treating obesity in both adolescents and adults [11–14]. A recent report showed that substantial weight loss induced by MBS improved COVID-19 infection outcomes including 49% lower risk of hospitalization (adjusted hazard ratio [HR], 0.51; 95% CI, 0.35–0.76; \( P < 0.001 \)), 63% lower risk for need of supplemental oxygen use (adjusted HR, 0.37; 95% CI, 0.23–0.61; \( P < 0.001 \)), and 60% lower risk of severe COVID-19 infection (adjusted HR, 0.40; 95% CI, 0.18–0.86; \( P = 0.02 \)) [15]. The authors concluded that obesity can be a modifiable risk factor for the severity of COVID-19 infection. However, there is little information available in the literature on the safety and utilization of MBS performed during the COVID-19 pandemic in the US. Other global studies have shown encouraging findings in that 30-day morbidity and mortality prevalence estimates following MBS during COVID-19 were similar to those before the pandemic [2]. Therefore, we report here the utilization and health and safety outcomes of MBS during 2020 versus previous years in the US youth (≤19 years old) and adult (>19 years old) populations, and by ethnic group. We hypothesized that MBS utilization rates decreased in 2020 versus 2015–2019 for both adults and youth but there was no change in safety outcomes.

Methods

Study Design

The merged 2015–2020 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) participant use files were used for this analysis \((N = 1,128,846)\). A prospective (30-day) cohort design was used for analysis. The database includes patient demographic characteristics, laboratory data, comorbidities, and complications within 30-day post-MBS. A retrospective analysis of datasets was conducted.

Data Sources

MBS Prevalence Estimates

In 2012, the American College of Surgeons (ACS) and the American Society for Metabolic and Bariatric Surgery (ASMBS) merged their MBS accredited programs into the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) [16]. The merged 2015–2020 MBSAQIP participant use files (PUF) were used for this analysis \((N = 1,128,846)\). The MBSAQIP PUF is a clinical data set of MBS patients who received their clinical care at an accredited center. The database includes Health Insurance Portability and Accountability Act (HIPAA)—compliant data such as patient demographic characteristics, laboratory data, comorbidities, and complications within 30-day post-MBS [17]. Data are collected at each accredited center by certified MBS clinical reviewers who undergo audits for reliability and consistency [16]. The PUF does not identify healthcare providers or hospitals, region, or area of surgery, and no personal health information is reported. Patients with age data missing \((n = 692)\) were excluded from our analysis.

Participants

The final analytical sample of the 2020 PUF contains 168,568 cases submitted from 885 centers; the 2019 PUF contains 206,570 cases submitted from 868 centers; the 2018 PUF contains 173 HIPAA compliant variables on 201,180 cases submitted from 854 centers; the 2017 file contains 197,175 cases submitted by 832 centers; the 2016 file contains 184,004 cases submitted by 791 centers; and the 2015 file contains data on 166,216 cases from 742 centers. Based on the World Health Organization definition [18], adolescents were defined as those <19 years old.

The University of Texas Health Science Center institutional review board determined that as a retrospective analyses of public, anonymized datasets, the MBSAQIP Data Registry is exempt from review.

Statistical Analysis

Descriptive analysis was performed for baseline characteristics, and youth and adult samples were compared. A Cochran-Armitage trend test was run to compare the following outcomes over time from 2015 to 2020; MBS utilization, mortality, reoperation, readmission, stroke, intraoperative/post myocardial infarction (MI), pulmonary embolism, post-operative deep vein thrombosis (DVT), septic shock, and sepsis. The Cochran–Armitage test [19, 20], a modified version of the Pearson chi-square test, for trend was run to compute \( P \) trend to assess the association between categorical variables and an ordinal variable (e.g., time). Generally speaking, \( P \) trend tests describes whether the overall trend over time is significant or not. Additionally, MBS completion was compared by ethnic group. Chi-squared tests were
used for univariate comparison of categorical predictors including sex, race/ethnicity, categorical pre-op BMI, categorical highest pre-op BMI, procedure type, hypertension, hyperlipidemia, type 2 diabetes, gastroesophageal reflux disease (GERD), sleep apnea, and chronic steroid use. A two sample (independent groups) t test was performed to determine if mean age differed.

Two multivariable logistic regression models were built to calculate the odds of hospital readmission and MBS completion pre-pandemic (2015–2019) versus during pandemic (2020) by demographics and comorbidities. The following were analyzed as binary (YN) predictors: hypertension, hyperlipidemia, type 2 diabetes, GERD, sleep apnea, and chronic steroid use with no presence of these conditions as the reference. The variable sex was also entered as a binary predictor with female as the reference group. Race/ethnicity was analyzed as a four-level categorical predictor that included non-Hispanic White (NHW), Hispanic, non-Hispanic Black (NHB), and other/multiracial (Asian, American Indian, and others) with NHW as the reference category. All statistical analysis was performed using SAS v9.4 (SAS Institute, Cary, NC). The type one error was maintained at 5%.

**Results**

Table 1 shows the pre-operative characteristics of US youth (≤19 years old) and adult (>19 years old) patients who completed MBS in 2015–2020. The mean age for youth was 17.88 (SD 1.24) years and for adults was 45.31 (SD 11.91) years. More females completed a bariatric procedure than males for both youth (76.88%) and adults (80.76%) (P < 0.001). Among adult MBS completers, 58.46% were NHW, 16.58% were NHB, 15.63% were other/multiracial, and 9.34% were Hispanic. Among youth, 45.48% were NHW, 20.03% were NHB, and other/multiracial (Asian, American Indian, and others) with NHW as the reference category.

Total body (percent) weight loss (TBWL) was computed by subtracting weight at 30 days from the pre-surgery weight then multiplying this by one hundred and dividing by the pre-surgery weight. Average TBWL in youth was 6.61% (SE = 0.18) and 5.82% (SE = 0.01) for adults at 30-day post-MBS (P = 0.009). The mean weight loss among youth was 7.88 kg (SE = 0.2) and 6.63 kg in adults (SE = 0.02) at 30-day post-MBS (P < 0.001) (data not shown on tables).

Table 2 compares 30-day morbidity and mortality for youth and adults who completed MBS pre-COVID-19 pandemic and during the first year of the pandemic. Among youth, the number of reoperations (1.47% in 2015, 1.24% in 2016, 0.59% in 2017, 1.18% in 2018, and 0.72% in 2019 versus 0.35% in 2020, P trend = 0.006) and reinterventions (1.47% in 2015, 1.93% in 2016, 0.71% in 2017, 0.59% in 2018, and 0.41% in 2019 versus 0.61% in 2020, P trend < 0.001) significantly decreased over the 6-year time frame. Other complications were rare. Among adults, 30-day post-MBS mortality, reoperations, readmissions, and reinterventions all showed significant decrease over time (P trend < 0.001) while septic shock and sepsis significantly increased from pre-pandemic to the first year of the pandemic (P trend < 0.001).

The total number of MBS procedures performed in 2020 during the first year of the pandemic in youth and adults was 1,140 and 167,384, respectively. MBS increased 8.1% in youth and decreased 10.2% among adults from 2019 to 2020, respectively. Among NHW, NHB, and Hispanic youth, there were significant upward trends in MBS utilization in 2020 compared to previous years (P trend < 0.001 for NHW, NHB, and other/multiracial, and P trend = 0.015 for Hispanic). Interestingly, MBS significantly increased by 18.5% during the pandemic for youth who identified as Other/Multi-race ethnicity (P trend < 0.001) (Fig. 1A). In contrast, the number of surgeries significantly decreased in US adults for all ethnic groups (all P trend < 0.001) (Fig. 1B).

Logistic regression results showed that adult males were 8% less likely than females to be readmitted post-MBS (OR 0.92, 95% CI, 0.89–0.94) (Table 3). Among adults only, NHW (OR 1.45, 95% CI, 1.42–1.49) were more likely than NHB patients to be readmitted post-MBS. Both youth and adults who completed the laparoscopic sleeve gastrectomy procedure were less likely than patients who completed the Roux-en-Y gastric bypass procedure to be readmitted post-MBS (OR 0.43, 95% CI, 0.30–0.61 for youth; OR 0.49, 95% CI, 0.48–0.50 for adults). Adults with hypertension, hyperlipidemia, type 2 diabetes, GERD, and sleep apnea were more likely to be readmitted versus those without comorbidities. For youth, those with hypertension and sleep apnea were more likely to be readmitted. Both youth and adults with chronic steroid use were more likely to be readmitted versus those who did not use this medication (OR 3.19, 95% CI, 1.23–8.28 for youth; OR 1.50, 95% CI, 1.41–1.59 for adults) (Table 3).
Table 4 shows the logistic regression results of completing MBS during the pandemic versus pre-pandemic for youth and adults by patient characteristics and comorbidity status. Among youth, those who identified as other/multi-racial were 71% more likely to complete MBS during the first year of the pandemic versus previous years (OR 1.71, 95% CI, 1.45–2.01), 47% more likely to complete the laparoscopic sleeve gastrectomy procedure versus the Roux-en-Y gastric bypass procedure (OR 1.47, 95% CI, 1.21–1.80), and 26% more likely to report having sleep apnea (OR 1.26, 95% CI, 1.07–1.50) versus youth who completed MBS pre-pandemic. Among adults, women were 6% more likely than men to complete MBS (OR 0.94, 95% CI, 0.93–0.96) and all ethnic groups including Hispanics (OR 1.06, 95% CI, 1.04–1.08), NHB (OR 1.20, 95% CI, 1.18–1.21), and other/multi-racial (OR 1.24, 95% CI, 1.22–1.25) were significantly more likely to complete MBS in 2020 versus pre-pandemic (P < 0.001 for all). Adults were 11% less likely to complete the laparoscopic sleeve gastrectomy procedure versus the Roux-en-Y gastric bypass procedure (OR 0.89, 95% CI, 0.88–0.90), 9% less likely to have hypertension (OR 0.91, 95% CI, 0.90–0.93), and 11% less likely to have type 2 diabetes (OR 0.89, 95% CI, 0.87–0.90) versus pre-pandemic MBS completers. However, they were 2% more likely to have hyperlipidemia (OR 1.02, 95% CI, 1.01–1.04), 6% more likely to have gastroesophageal reflux disease (OR 1.06, 95% CI, 1.04–1.07), 4% more likely to have sleep apnea (OR 1.04, 95% CI, 1.03–1.06), and 20% more likely...
Table 2 Comparison of 30-day mortality and morbidity for patients who completed bariatric surgery among US youth and adults, pre-COVID-19 pandemic, and during the first year of the pandemic, MBSAQIP data, 20,152,020

|                         | Pre-pandemic | Pandemic | P trend*   |
|-------------------------|--------------|----------|-----------|
|                         | 2015         | 2016     | 2017      | 2018      | 2019      | 2020      |          |
| Bariatric procedures, n | 1154         | 726      | 841       | 845       | 970       | 1140      |          |
| Mortality, n (%)        | 1 (0.08%)    | 0 (0)    | 0 (0)     | 2 (0.24%) | 0 (0%)    | 0 (0)     | 0.592     |
| Reoperation, n (%)      | 17 (1.47%)   | 9 (1.24%)| 5 (0.59%) | 10 (1.18%)| 7 (0.72%) | 4 (0.35%) | 0.006     |
| Readmission, n (%)      | 39 (3.38%)   | 26 (3.58%)| 24 (2.85%)| 25 (2.96%)| 29 (2.99%)| 24 (2.11%)| 0.066     |
| Reintervention, n (%)   | 17 (1.47%)   | 14 (1.93%)| 6 (0.71%) | 5 (0.59%) | 4 (0.41%) | 7 (0.61%) | <0.001    |
| Stroke, n (%)           | 0 (0)        | 0 (0)    | 0 (0)     | 0 (0)     | 0 (0)     | 0 (0)     |          |
| Intraoperative/post MI, n (%) | 0 (0)       | 0 (0)    | 0 (0)     | 0 (0)     | 0 (0)     | 0 (0)     | -         |
| Pulmonary embolism, n (%) | 1 (0.09%) | 0 (0)    | 1 (0.12%) | 1 (0.12%) | 1 (0.10%) | 0 (0)     | 0.733     |
| Post-operative DVT, n (%) | 0 (0)      | 0 (0)    | 2 (0.24%) | 0 (0)     | 1 (0.10%) | 1 (0.09%) | 0.444     |
| Septic shock, n (%)     | 0 (0)        | 0 (0)    | 0 (0)     | 0 (0)     | 0 (0)     | 0 (0)     | -         |
| Sepsis, n (%)           | 0 (0)        | 1 (0.14%)| 0 (0)     | 1 (0.11%) | 0 (0)     | 0 (0)     | 0.389     |

Adults (N = 1,128,846)

|                         | Pre-pandemic | Pandemic | P trend*   |
|-------------------------|--------------|----------|-----------|
|                         | 2015         | 2016     | 2017      | 2018      | 2019      | 2020      |          |
| Bariatric procedures, n | 166,894      | 185,987  | 199,442   | 203,907   | 205,232   | 167,384   | 167,384   |
| Mortality, n (%)        | 219 (0.13%)  | 207 (0.11%)| 201 (0.10%)| 235 (0.12%)| 239 (0.12%)| 130 (0.08%)| <0.001    |
| Reoperation, n (%)      | 2844 (1.70%) | 2894 (1.56%)| 3032 (1.52%)| 3087 (1.51%)| 3292 (1.60%)| 2027 (1.21%)| <0.001    |
| Readmission, n (%)      | 7739 (4.64%) | 7916 (4.26%)| 7862 (3.94%)| 8086 (3.97%)| 8302 (4.05%)| 5410 (3.23%)| <0.001    |
| Reintervention, n (%)   | 3108 (1.86%) | 3020 (1.62%)| 2816 (1.41%)| 2774 (1.36%)| 2836 (1.38%)| 1453 (0.87%)| <0.001    |
| Stroke, n (%)           | 21 (0.01%)   | 17 (0.01%)| 30 (0.02%)| 31 (0.02%)| 41 (0.02%)| 21 (0.01%)| 0.127     |
| Intraoperative/post MI, n (%) | 57 (0.03%) | 57 (0.03%)| 66 (0.03%)| 58 (0.03%)| 54 (0.03%)| 49 (0.03%)| 0.209     |
| Pulmonary embolism, n (%) | 205 (0.12%) | 216 (0.12%)| 231 (0.12%)| 257 (0.13%)| 271 (0.13%)| 233 (0.14%)| 0.044     |
| Post-operative DVT, n (%) | 308 (0.18%) | 336 (0.18%)| 353 (0.18%)| 388 (0.19%)| 438 (0.21%)| 363 (0.22%)| 0.001     |
| Septic shock, n (%)     | 38 (0.02%)   | 43 (0.02%)| 50 (0.03%)| 54 (0.03%)| 74 (0.04%)| 138 (0.08%)| <0.001    |
| Sepsis, n (%)           | 56 (0.03%)   | 76 (0.04%)| 69 (0.03%)| 93 (0.05%)| 82 (0.04%)| 206 (0.12%)| <0.001    |

*p value was computed by Cochran-Armitage trend test

Fig. 1  A Number of bariatric surgeries completed in 2015–2019 (pre-pandemic) versus 2020 (pandemic) in youth, overall, and by ethnicity. A Cochran-Armitage trend test was performed to compare the utilization numbers by time period for the overall sample and stratified by ethnic group. B Number of bariatric surgeries completed in 2015–2019 (pre-pandemic) versus 2020 (pandemic) in adults, overall, and by ethnicity. A Cochran-Armitage trend test was performed to compare the utilization numbers by time period for the overall sample and stratified by ethnic group.
to report chronic steroid use (OR 1.20, 95% CI, 1.16–1.24) versus pre-pandemic MBS completers (P < 0.001 for all).

**Discussion**

Results here showed that not surprisingly, MBS volume decreased 10% for adults, but perhaps surprisingly, increased by almost the same proportion among youth during the first year of the COVID-19 pandemic versus the previous 5 years. These discrepancies may be due to elective surgeries being canceled or delayed on several occasions throughout the year to accommodate patients admitted for COVID-19 illness among adults whereas the pandemic’s impact on pediatric morbidity and mortality was much less severe in 2020 when pre-Delta variants were predominant. However, data also showed that MBS can be performed safely during the pandemic without increased risk of complication or mortality to patients. These are encouraging findings as the world enters the third year of the pandemic in 2022.

**Table 3** Odds of hospital readmission for youth and adults by patient characteristics, comorbidity status, and pre-pandemic versus pandemic, MBSAQIP data, 2015–2020

| Variable                       | Youth                      | Adults                     |
|-------------------------------|----------------------------|----------------------------|
|                               | aOR (95% CI)a              | P valuea                   | aOR (95% CI)a              | P valuea                   |
| Gender                        |                            |                            |                            |                            |
| Female (ref)                  | 1.0                        | -                          | 1.0                        | -                          |
| Male                          | 0.74 (0.49–1.11)           | 0.142                      | 0.92 (0.89–0.94)           | <0.001                     |
| Race/ethnicity                |                            |                            |                            |                            |
| Non-Hispanic White (ref)      | 1.0                        | -                          | 1.0                        | -                          |
| Hispanic                      | 0.90 (0.59–1.37)           | 0.610                      | 1.03 (1.0–1.07)            | 0.073                      |
| Non-Hispanic Black            | 0.97 (0.63–1.51)           | 0.891                      | 1.45 (1.42–1.49)           | <0.001                     |
| Other, multiracial            | 0.65 (0.40–1.04)           | 0.072                      | 0.98 (0.95–1.01)           | 0.135                      |
| Procedure type                |                            |                            |                            |                            |
| LRYGB (ref)                   | 1.0                        | -                          | 1.0                        | -                          |
| LSG                           | 0.43 (0.30–0.61)           | <0.001                     | 0.49 (0.48–0.50)           | <0.001                     |
| Other                         | 0.58 (0.28–1.20)           | 0.139                      | 0.97 (0.94–0.99)           | 0.020                      |
| Hypertension                  |                            |                            |                            |                            |
| No (ref)                      | 1.0                        | -                          | 1.0                        | -                          |
| Yes                           | 1.06 (0.74–1.52)           | 0.753                      | 1.11 (1.08–1.13)           | <0.001                     |
| Hyperlipidemia                |                            |                            |                            |                            |
| No (ref)                      | 1.0                        | -                          | 1.0                        | -                          |
| Yes                           | .979                      | 1.10 (1.07–1.12)           | <0.001                     |
| Type 2 diabetes               |                            |                            |                            |                            |
| No (ref)                      | 1.0                        | -                          | 1.0                        | -                          |
| Yes                           | 0.92 (0.58–1.46)           | 0.710                      | 1.06 (1.04–1.08)           | <0.001                     |
| Gastroesophageal reflux disease |                           |                            |                            |                            |
| No (ref)                      | 1.0                        | -                          | 1.0                        | -                          |
| Yes                           | 1.07 (0.67–1.69)           | 0.783                      | 1.36 (1.34–1.39)           | <0.001                     |
| Sleep apnea                   |                            |                            |                            |                            |
| No (ref)                      | 1.0                        | -                          | 1.0                        | -                          |
| Yes                           | 1.44 (0.98–2.11)           | 0.065                      | 1.06 (1.04–1.08)           | <0.001                     |
| Chronic steroid use           |                            |                            |                            |                            |
| No (ref)                      | 1.0                        | -                          | 1.0                        | -                          |
| Yes                           | 3.19 (1.23–8.28)           | 0.017                      | 1.50 (1.41–1.59)           | <0.001                     |
| Pre-pandemic versus pandemic  |                            |                            |                            |                            |
| Pre-pandemic                  | 1.0                        | -                          | 1.0                        | -                          |
| Pandemic                      | 0.69 (0.42–1.14)           | 0.147                      | 0.74 (0.72–0.77)           | <0.001                     |

*aMultivariable logistic regression controlling for gender, race/ethnicity, procedure type, pre-surgery comorbidities including hypertension, hyperlipidemia, type 2 diabetes, gastroesophageal reflux disease, and sleep apnea, chronic steroid use, and pre-pandemic status*

bNot enough sample size to compute OR

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2020 versus the previous 5 years among US youth and adults, an international study showed that 30-day morbidity and mortality following completion of MBS during the COVID-19 pandemic was analogous to pre-pandemic levels [2]. Specifically, the international GENEVA cohort study reported 30-day morbidity and mortality outcomes in adults (≥ 18 years old) only for 2 and half months (May 1 to July 10, 2020) among 2001 adult patients from 127 hospitals in 35 countries. They reported the overall mortality rate was 0.05%, similar to pre-pandemic mortality rates reported by others [21–23]. Results here showed no deaths among youth and 0.08% among adults during 2020, which while slightly higher than these other reported mortality rates, were lower than those reported in 2015–2019 (0.10–0.13%). These results are reassuring given that the COVID-19 pandemic was widespread in the US from March to December 2020 and caused hundreds of thousands of deaths in the general population during that time period.

An unexpected finding was the overall increase, or sustenance in MBS utilization during the pandemic versus pre-pandemic for youth, and for all ethnicities. The steepest incline was among those identifying as other/multiracial, where an additional 105 surgeries were reported in 2020 versus 2019. This may reflect the overall US census trends that show a marked increase in individuals identifying as multiracial [24]. Nevertheless, this is an encouraging finding given that ethnic minorities are disproportionately impacted by severe obesity versus non-Hispanic Whites [25]. Specifically, as of 2016, approximately 9% of 12-to-19-year-olds had class II/III obesity, triple the prevalence

| Variable                        | Youth | Adults |
|---------------------------------|-------|--------|
|                                 | aOR (95% CI) | P value | aOR (95% CI) | P value |
| Gender                          |       |        |
| Female (ref)                    | 1.0   | -      | 1.0          | -      |
| Male                            | 0.90 (0.77–1.06) | 0.204 | 0.94 (0.93–0.96) | <0.001 |
| Race/ethnicity                  |       |        |
| Non-Hispanic White (ref)        | 1.0   | -      | 1.0          | -      |
| Hispanic                        | 0.87 (0.72–1.06) | 0.158 | 1.06 (1.04–1.08) | <0.001 |
| Non-Hispanic Black              | 1.16 (0.96–1.41) | 0.139 | 1.20 (1.18–1.21) | <0.001 |
| Other, multirace                | 1.71 (1.45–2.01) | <0.001 | 1.24 (1.22–1.25) | <0.001 |
| Procedure type                  |       |        |
| LRYGB (ref)                     | 1.0   | -      | 1.0          | -      |
| LSG                             | 1.47 (1.21–1.80) | <0.001 | 0.89 (0.88–0.90) | <0.001 |
| Other                           | 0.76 (0.50–1.15) | 0.191 | 0.46 (0.45–0.47) | <0.001 |
| Hypertension                    |       |        |
| No (ref)                        | 1.0   | -      | 1.0          | -      |
| Yes                             | 0.89 (0.68–1.16) | 0.389 | 0.91 (0.90–0.93) | <0.001 |
| Hyperlipidemia                  |       |        |
| No (ref)                        | 1.0   | -      | 1.0          | -      |
| Yes                             | 1.15 (0.73–1.82) | 0.538 | 1.02 (1.01–1.04) | 0.002 |
| Type 2 diabetes                 |       |        |
| No (ref)                        | 1.0   | -      | 1.0          | -      |
| Yes                             | 0.92 (0.75–1.13) | 0.444 | 0.89 (0.87–0.90) | <0.001 |
| Gastroesophageal reflux disease |       |        |
| No (ref)                        | 1.0   | -      | 1.0          | -      |
| Yes                             | 0.86 (0.69–1.07) | 0.185 | 1.06 (1.04–1.07) | <0.001 |
| Sleep apnea                     |       |        |
| No (ref)                        | 1.0   | -      | 1.0          | -      |
| Yes                             | 1.26 (1.07–1.50) | 0.007 | 1.04 (1.03–1.06) | <0.001 |
| Chronic steroid use             |       |        |
| No (ref)                        | 1.0   | -      | 1.0          | -      |
| Yes                             | 0.61 (0.27–1.35) | 0.223 | 1.20 (1.16–1.24) | <0.001 |

*Multivariable logistic regression controlling for gender, race/ethnicity, procedure type, pre-surgery comorbidities including hypertension, hyperlipidemia, type 2 diabetes, gastroesophageal reflux disease, and sleep apnea, and chronic steroid use.
from 1988 to 1994 [26]. Classes II and III of obesity are defined as having a BMI <140% and a BMI ≥140% of the 95th percentile for age and sex, respectively. Reports show that from 2015 to 2018, the US prevalence of youth with severe obesity increased in Hispanics and NHB (P trend <0.001), but NHW youth had higher rates of MBS utilization (45.8%) compared to Hispanics (22.7%) and NHB 14.2% (P=0.006) [11]. Moreover, the Centers for Disease Control and Prevention recently analyzed BMI change among a cohort of 432,302 persons aged 2–19 years before and during the COVID-19 pandemic (January 1, 2018–February 29, 2020 and March 1, 2020–November 30, 2020, respectively) [8]. Results showed that between the pre-pandemic and pandemic periods, the rate of BMI increase approximately doubled, from 0.052 kg/m²/month (95% CI, 0.051–0.052) to 0.100 (95% CI, 0.098–0.101) (ratio = 1.93 [95% CI, 1.90–1.96]). Even more alarmingly, results showed those who were overweight or had obesity during the pre-pandemic period experienced significantly higher rates of BMI increase during the pandemic period compared to those with healthy weight. Similarly, a retrospective cohort study by Woolford et. al. [7] using data from Kaiser Permanente Southern California electronic health records found that the prevalence of being overweight or having obesity among 5- to 11-year-olds increased from 36.2% before the pandemic to 45.7% during the pandemic. A recent meta-analysis showed the prevalence of obesity has increased since the start of the pandemic, leading the authors to conclude the worsening burden of childhood obesity worldwide [27]. Similar results have been reported in adults [10, 28]. While these reports are discouraging, our results show that MBS utilization among youth with severe obesity has not only increased during the first year of the pandemic but is on par for some of the highest rates over the past 6 years (only 2015 was higher with 14 more surgeries). Over the past year, MBS procedures among NHB and Hispanic youth were consistent (182 total in 2019 and 2020 for NHB, 180 in 2019 and 179 in 2020 for Hispanic youth), while procedures increased among NHW (from 398 in 2019 to 459 in 2020) and other/multiracial ethnicity by 20%. Moving forward, it will be important to analyze 2021 MBS utilization and health outcomes data when it becomes available to determine if the trends noted here continue for a second year, especially in light of several reports of an overall increase in obesity in the general population, both before and during the pandemic. This will be particularly important to analyze in Hispanic and NHB youth, who had a slight decline from 2018 to 2019 in MBS utilization but remained stable in 2020.

Results showed a roughly doubling of septic shock (0.04 to 0.08%) and a tripling of sepsis (0.04 to 0.12%) from 2019 to 2020. While these prevalence estimates remain very low overall, various aspects of the COVID-19 pandemic may be impacting these 2-year trends. For example, patients with more comorbidities and health complications may not have been able to access healthcare pre-operatively in 2020 with as much ease as previous years. Surgical units and hospitals may have been overburdened with COVID patients, and thus the identification of illness was delayed until sepsis was diagnosed. Finally, there may be patients who recovered from COVID recently among the 2020 MBS completers who have unidentified health challenges and complexities. Nevertheless, it will be important to examine 2021 and 2022 MBSAQIP data when it becomes available to determine if this is more than a spurious association.

Finally, results showed that adult were 11% less likely, and youth were 47% more likely to complete the LSG procedure versus the LRYGB procedure during the pandemic, and that both age groups were less likely to have hypertension and type 2 diabetes and more likely to have hyperlipidemia and sleep apnea versus those completing surgery pre-pandemic. Adults only were more likely to report GERD and chronic steroid use versus pre-pandemic MBS completers. The increase in LRYGB versus LSG may suggest surgeons prioritized greater medically necessary, time sensitive patients that needed a LRYGB procedure to address more severe medical conditions. However, it is challenging to make any strong conclusions given that patients with other comorbidities, namely type 2 diabetes and hypertension, were less likely to complete MBS during the pandemic. When available, the MBSAQIP 2021 data will provide more insight into the longitudinal patterns of types of surgeries performed during the pandemic, and if trends continued in terms of the prioritization of certain comorbidities over others.

Some limitations should be noted concerning this analysis. Only MBSAQIP center data was used for this analysis, and thus our outcomes are not representative of all MBS practices in the nation. However, a recent analysis of both MBSAQIP and National Inpatient Survey (NIS) data that included both adolescents and adults reported that in 2018 approximately 80% of surgeries are performed at MBSA-QIP-accredited centers. Moreover, NIS data showed only 8% of MBS centers were non-accredited in 2015–2016 and this decreased to 4.9% in 2018 [29]. Perioperative data was only available for 30-day post-MBS which limits longer term capture of weight loss measures and complication rates. However, the primary purpose of this study was not to examine the outcome of MBS, but rather the focus was on capturing the most recent national MBS utilization data and during the first year of the COVID-19 pandemic, especially given the reports in weight gain among both youth and adults during the pandemic. While the MBSAQIP database maintains a rigorous auditing process for data accuracy, some cases may contain errors or omissions that could produce reporting bias. We were not able to examine the impact of insurance coverage on the MBS utilization rate due to data unavailability; however, insurance is not the only influential factor for MBS utilization [30]. Indeed, our group [31, 32]
as well as others [33–35] have shown that there are a number of socioecological (intra- and inter-personal, community, and policy) factors that drive the decision to complete MBS among patients from a variety of ethnic backgrounds. Also, other important factors such as age and comorbidities have been rigorously controlled in this study. Finally, the database does not document surgical variation in intraoperative technique, which may affect patient outcomes.

Conclusions

MBS volume increased almost 10% for youth but decreased by the same proportion among adults during the first year of the COVID-19 pandemic. Among adults, this finding is most likely due to elective surgeries being cancelled or delayed on several occasions in 2020 to accommodate patients admitted for COVID-19 illness. MBS can be performed safely during the pandemic without increased risk of complication or mortality to patients. There was an increase in MBS utilization during the pandemic versus pre-pandemic for youth of all ethnic backgrounds. It will be important to analyze 2021 MBS utilization and health outcomes data when it becomes available to determine if the trends noted here continue for a second year, especially in light of several reports of an overall increase in obesity in the general population both before and during the pandemic.

Acknowledgements The authors would like to thank the American Society for Metabolic and Bariatric Surgery and the American College of Surgeons for the use of 2015–2020 MBSAQIP PUF for this analysis.

Declarations

Ethics Approval For this type of study formal consent is not required.

Conflict of Interest The authors declare no competing interests.

Informed Consent Informed consent does not apply.

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