Patterns of Bariatric Surgeries Among U.S. Women Diagnosed with Polycystic Ovarian Syndrome

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Abstract

Background: To examine patterns and outcomes of bariatric surgeries, including Roux-en-Y gastric bypass (RYGB), laparoscopic sleeve gastrectomy (LSG) and laparoscopic adjustable gastric banding (LAGB), among women diagnosed with polycystic ovarian syndrome (PCOS).

Materials and Methods: Retrospective cohort study using 1998–2011 Nationwide Inpatient Sample data. A total of 52,668 hospital discharge records met eligibility criteria among PCOS women, 18–49 years. Of those, 17,759 had an obesity/overweight diagnosis and 4310 underwent bariatric surgery. Furthermore, 3086 underwent RYGB ($n=2411$), LSG ($n=126$), or LAGB ($n=549$), and were compared to 78,931 non-PCOS controls. Multiple regression models were constructed to examine patient- and hospital-level predictors of obesity/overweight and bariatric surgery, as well as type of bariatric surgery (RYGB, LSG, or LAGB) as a predictor of in-hospital outcomes and PCOS status.

Results: The prevalence of obesity/overweight ($\approx 34\%$) among women diagnosed with PCOS, and of bariatric surgery ($\approx 24\%$) among women diagnosed with PCOS and obese/overweight varied by patient- and hospital-level characteristics. Women having PCOS and overweight/obesity, who underwent LSG or LAGB, had shorter hospital stay, reduced hospital charges, and better disposition at discharge compared to those who underwent RYGB. PCOS cases and non-PCOS controls experienced similar treatment selection and in-hospital outcomes after bariatric surgery. Also, PCOS cases and non-PCOS controls experienced similar in-hospital outcomes after undergoing RYGB, LSG, or LAGB.

Conclusions: Compared to RYGB, LSG and LAGB resulted in improved in-hospital outcomes among obese/overweight PCOS and non-PCOS patients. Further research is needed to examine health care disparities in the context of PCOS, obesity/overweight, and bariatric surgery.

Keywords: bariatric surgery, infertility, obesity, overweight, polycystic ovarian syndrome

Introduction

ORIGINALLY DESCRIBED BY Stein and Leventhal, polycystic ovarian syndrome (PCOS) is a heterogeneous disorder that remains the most frequently diagnosed endocrinopathy among women of childbearing age and a leading cause of infertility.^{1–4} The principal features of PCOS are clinical and/or biochemical androgen excess (hyperandrogenemia), ovulatory dysfunction, and polycystic ovaries.^{1,3} The prevalence of PCOS is estimated at 5%–20% among reproductive-aged women.^{1,3–5} Furthermore,

PCOS has been associated with increased risks of obesity, insulin resistance, impaired glucose tolerance, type 2 diabetes mellitus, dyslipidemia, hypertension, metabolic syndrome, cardiovascular disease, sleep apnea, and endometrial cancer.^{1,3,5,6}

A substantial proportion of women diagnosed with PCOS are obese or overweight (40%–70%), or have insulin resistance (50%–70%).^{7–9} In addition, nearly 40% of PCOS women may develop type 2 diabetes by 50 years of age, often irrespective of their obesity status.³ Thus, treatment modalities for PCOS have considered obesity and its related chronic

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conditions as comorbidities that should be addressed simultaneously. Lifestyle modification through diet and physical exercise is the principal choice for managing obesity and its associated chronic conditions among PCOS women, potentially improving fertility.^{1,3,10} However, weight loss achieved in the short term, through lifestyle modifications, may not be sustainable in the long term.^{3,11,12} Pharmacological treatments address various aspects of PCOS, including insulin resistance (*e.g.*, metformin and pioglitazone), menstrual abnormalities, hirsutism, and acne (*e.g.*, hormonal contraceptives), endocrine-metabolic disorders (*e.g.*, inositols), and obesity (*e.g.*, orlistat), among others.¹³ Presently available obesity drugs have raised safety concerns due to unknown teratogenic effects among reproductive-age women.¹⁰ In contrast, current evidence supports bariatric surgery as more effective than nonsurgical treatments at achieving sustained weight loss, while mitigating obesity-related health problems, including type 2 diabetes, hypertension, dyslipidemia, metabolic syndrome, sleep apnea, and osteoarthritis.^{3,14,15}

Picot et al. evaluated the clinical effectiveness of bariatric surgery among obese patients by conducting a systematic review of studies, whereby frequently used open and laparoscopic bariatric surgical procedures were compared with each other or with nonsurgical treatments.¹⁴ Based on 26 studies (3 randomized controlled trials [RCTs] and 3 cohort studies comparing surgical with nonsurgical interventions and 20 RCTs comparing distinct surgical procedures), bariatric surgery was found to be more effective for weight loss and reduction in obesity-related morbidities, including metabolic syndrome and type 2 diabetes, than nonsurgical options.¹⁴ For instance, a large cohort study found that weight loss had persisted 10 years after bariatric surgery, whereas patients who received nonsurgical treatments had gained weight.¹⁴ Comparative studies of surgical procedures found that gastric bypass (GBP) was more effective for weight loss than vertical banded gastroplasty (VBG) and adjustable gastric banding (AGB), whereas laparoscopic isolated sleeve gastrectomy (LISG) was more effective than AGB in one study.¹⁴ GBP and banded GBP resulted in similar weight loss, whereas studies comparing GBP to LISG and VBG to AGB were equivocal.¹⁴ Finally, comparisons of open versus laparoscopic surgeries found no significant group differences in terms of weight losses.¹⁴

With the expanded use of bariatric surgery beyond morbid obesity, PCOS has become a novel indication in recent years.³ While obesity adversely affects pregnancy and fetal-maternal outcomes, obese women with subfertility, including those diagnosed with PCOS, may achieve spontaneous pregnancy after undergoing bariatric surgery.^{3,13,16} In addition, bariatric surgery may reduce the risks of preeclampsia and gestational diabetes, although it may increase the risk of small-for-gestational age, stillbirth, and neonatal death.³ Limited evidence suggests that women diagnosed with PCOS may experience sustained weight loss and improved cardiometabolic risk profile, as well as fertility, after undergoing bariatric surgeries, including Roux-en-Y gastric bypass (RYGB), laparoscopic sleeve gastrectomy (LSG), and laparoscopic adjustable gastric banding (LAGB).^{3,4,10,16}

Despite its potential for achieving positive outcomes, utilization of bariatric surgeries among hospitalized PCOS women has not been previously characterized at the national level. However, recent reports have examined trends, pre-

dictors, and outcomes of bariatric surgery utilization among other clinical subpopulations,^{17–21} using a representative sample of hospitalized U.S. patients. In this retrospective cohort study of hospital discharges from the 1998 to 2011 Nationwide Inpatient Sample (NIS), we examined patterns and outcomes of bariatric surgeries, including RYGB, LSG, and LAGB, among women diagnosed with PCOS. In particular, we examined obesity/overweight by patient- and hospital-level characteristics among PCOS-diagnosed women. Among PCOS women having obesity/overweight, we examined patient- and hospital-level characteristics as predictors of utilization of bariatric surgeries as well as bariatric surgeries as predictors of length of hospital stay, hospitalization charges, and nonroutine disposition at discharge. Finally, we compared PCOS and non-PCOS women who were obese or overweight and underwent specific bariatric surgeries on type of surgery, length of hospital stay, hospitalization charges, and nonroutine disposition at discharge.

Materials and Methods

Data source

The Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP) NIS is the largest public-use all-payer database in the United States that provides national estimates of health care utilization and related outcomes. The NIS was selected using a 20% stratified sample of the community hospitals participating in the HCUP State Inpatient Databases. Each year, data were collected from ~1000 hospitals and the sampling frame of hospitals was divided into multiple strata according to hospital ownership/control, bed size, teaching status, urban/rural location, and U.S. region. NIS samples were selected with probabilities proportionate to the number of hospitals within each of the five stratifying variables. Given the low prevalence of PCOS diagnoses in the NIS database, and due to changes in sampling design starting in 2012, we restricted our sample to the 1998–2011 14-year period. The NIS contains data elements typical of a discharge abstract, including patient- and hospital-level characteristics. The original research project as designed by AHRQ was approved by an Institutional Review Board in accordance with principles outlined by the Declaration of Helsinki.

Study population and sample

Secondary analyses were performed using 1998–2011 NIS data, with specific inclusion and exclusion criteria applied to define the study population. For population 1 (women diagnosed with PCOS), hospital discharge records were kept if they satisfied the following inclusion criteria: (1) female sex; (2) age ranging between 18 and 49 years; (3) International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnostic code of 256.4 indicating the presence of PCOS. For population 2 (women diagnosed with PCOS and obesity/overweight), the following additional inclusion criterion was applied: (4) ICD-9-CM diagnostic code of obesity/overweight (V85.3x [body mass index—BMI, 35.0–39.9 kg/m²], V85.4x [BMI, >40 kg/m²], V77.8 [obesity], 278.0 [overweight and obesity], 278.00 [obesity unspecified], 278.01 [morbid obesity], and 278.02 [overweight]). For population 3 (women diagnosed with PCOS and obesity/overweight who

underwent bariatric surgeries), the following additional inclusion criteria were also applied: (5) ICD-9-CM procedure codes indicating bariatric surgery status (V45.86), complications of bariatric procedures (539.xx), bariatric surgery status complicating pregnancy, childbirth, or the puerperium (649.2x) or bariatric surgeries (43.89, 44.31, 44.38, 44.39, 44.50, 44.68, 44.69, 44.93, 44.95, 44.99, 45.51, and 45.90); or (6) at least one of the following types of bariatric surgeries: (a) RYGB (open or laparoscopic) (44.38 or [44.31, 44.3, and 44.39] with laparoscopy [54.21] or with conversion from laparoscopic to open procedure [V64.4, V64.41]), (b) LSG (43.82 and 44.68), or (c) LAGB (44.95). Furthermore, hospital discharge records were removed in populations 1–3 if they satisfied the following exclusion criteria: ICD-9-CM diagnostic codes of (1) malignant neoplasm of digestive organs or peritoneum (150–159.9), (2) inflammatory bowel disease (555–556.9), (3) noninfectious colitis (557–558.9), (4) familial adenomatous polyposis (211), (5) adiposogenital dystrophy (253.8), (6) obesity of endocrine origin not otherwise specified (259.9), or (7) missing data on exposures, outcomes, and/or covariates pertaining to specific analyses. Finally, a control group was selected that met aforementioned inclusion/exclusion criteria for non-PCOS obese/overweight women, 18–49 years, who underwent RYGB, LSG, or LAGB (population 4). These eligibility criteria were selected based on recently published reports that analyzed data from the NIS with an emphasis on bariatric surgery.^{18–20,22–26}

Measures

Obesity/overweight diagnosis was defined based on ICD-9-CM diagnostic codes as a dichotomous (yes or no) variable. Among obese/overweight PCOS women, bariatric surgery utilization was defined as a dichotomous (yes or no) variable and type of bariatric surgery was categorized as follows: (1) RYGB, (2) LSG, (3) LAGP, (4) Other, and (5) Unspecified. In comparative analyses, RYGB was selected as the referent group, since it is the most frequently utilized bariatric surgery type, and discharge records having “Other” or “Unspecified” types of bariatric surgeries were excluded. Outcome variables were defined using existing data elements from the NIS database, namely, disposition (“Discharged to home or self-care” (referent), “Transferred to short-term hospital, transferred to other type of facility, home healthcare, against medical advice, discharged to court or law enforcement, or died in hospital”), length of hospital stay (in “days”), and hospital charges (in “U.S. dollars,” adjusted for 1998–2011 inflation rates (www.in2013dollars.com/Hospital-services/price-inflation/1998-to-2011?amount=1)). The two continuous outcomes (length of hospital stay and hospital charges) were log_e-transformed because of skewed distributions. Patient-level and hospital-level characteristics were defined as follows: age (continuous, “18–19,” “20–24,” “25–29,” “30–34,” “35–39,” “40–44,” and “45–49” “years”), race/ethnicity (“White,” “African American,” “Hispanic,” and “Other”), Charlson comorbidity index (“0,” “1,” and “2+”), year of admission (“1998”–“2011”), admission quarter (“1st quarter,” “2nd quarter,” “3rd quarter,” and “4th quarter”), weekend admission status (“Monday–Friday” and “Saturday–Sunday”), primary payer (“Medicare,” “Medicaid,” “Private insurance,” “Self-pay,” “No pay,” and “Other”), hospital region (“Northeast,” “Midwest,”

“South,” and “West”), hospital control (“Government or Private,” “Government, non-federal,” “Private, not-for-profit,” “Private, investor-owned,” and “Private”), hospital location and teaching status (“Rural,” “Urban—Non-Teaching,” and “Urban—Teaching”), and hospital bed size (“Small,” “Medium,” and “Large”).

Statistical analysis

All statistical analyses were conducted using STATA version 15 (StataCorp, College Station, TX), taking complex survey design into consideration. Descriptive statistics included mean ($\pm$ standard error) for continuous variables and frequencies with percentages for categorical variables. Bivariate associations were examined using uncorrected Chi-square and design-based *F*-tests. Linear and binary logistic regression models were constructed to estimate crude and adjusted beta coefficients, as well as odds ratios (cOR and aOR) with their 95% confidence intervals (CIs). Complete subject analyses were performed based on available subsamples for variables under evaluation. Two-sided statistical tests were conducted and $p < 0.05$ was considered statistically significant.

Results

A total of 53,899 hospital discharge records from the 1998 to 2011 NIS database were identified as corresponding to female patients, 18–49 years of age, who were diagnosed with PCOS. After excluding patients diagnosed with malignant neoplasms of digestive organs or peritoneum, inflammatory bowel disease, noninfectious colitis, familial adenomatous polyposis, adiposogenital dystrophy, and/or obesity of endocrine origin not otherwise specified, 52,668 hospital discharge records remained in population 1. Of those, 17,759 records corresponded to women diagnosed with PCOS and obesity/overweight (population 2) and 4310 records corresponded to women diagnosed with PCOS and obesity/overweight, who underwent bariatric surgeries, including RYGB ($n = 2411$), LSG ($n = 126$), and LAGB ($n = 549$; population 3) (Fig. 1). Subsequent analyses were based on subsamples of populations 1–3 with valid data on key variables of interest.

Table 1 presents the patient- and hospital-level characteristics of 52,057 hospital discharge records for women, 18–49 years of age, diagnosed with PCOS, and with no missing data on key variables according to obesity/overweight diagnosis. Of these women, 17,566 were obese/overweight, whereas 34,491 were not obese/overweight. The prevalence of obesity/overweight was estimated at 34% (95% CI: 33%–35%), with significant variability according to all selected patient-level and hospital characteristics, except for discharge quarter, hospital region, location/teaching status, and bed size. In a fully adjusted multiple logistic regression model, obesity/overweight was positively associated with patients who were ≥ 40 years, African American or Hispanic, had 1+ comorbidities, or were admitted after 2001, and negatively associated with patients of other race and those admitted on weekends or to governmental, nonfederal hospitals. Compared to Medicare recipients, those reporting Medicaid, private, or other type of insurance were less likely to be obese/overweight. Of note, the prevalence of obesity/overweight among hospitalized PCOS women increased

FIG. 1. Study flowchart—nationwide inpatient sample (1998–2011).

steadily from 15% to 39% between 1998 and 2011, mirroring the epidemic reported in other surveillance systems.

Table 2 presents bariatric surgery status by characteristics of hospital discharges for obese/overweight women, 18–49 years of age, diagnosed with PCOS, using a total of 17,566 hospital discharge records, of which 4265 corresponded to patients who underwent a bariatric surgery and 13,301 corresponded to patients who did not undergo a bariatric surgery. Overall, the prevalence of bariatric surgery in this population was 24.1% (95% CI: 21.8%–26.5%). Fully adjusted multiple logistic regression model identified several groups of patients at increased or decreased odds of bariatric surgery. Patients 20 years and older, those with one comorbidity, those admitted after 2001, reporting self-pay, private, or other type of insurance, and those receiving care at private, investor-owned, or urban hospitals were more likely to have undergone bariatric surgery than their counterparts. By contrast, African American race, 2+ comorbidities, weekend admission, and hospital regions outside of Northeast predicted fewer bariatric surgeries. Of note, bariatric surgery rates increased steadily from 8% to 32% between 1998 and 2005, and declined or tapered off thereafter to reach 22% in 2011.

On average, women diagnosed with PCOS were hospitalized for 3.64 ± 0.05 days (obese/overweight: 3.64 ± 0.06 vs. not obese/overweight: 3.64 ± 0.06 , $p = 0.96$), with hospital charges of $\$38,809 \pm 864$ (obese/overweight: $\$48,739 \pm 1182$ vs. not obese/overweight: $\$33,803 \pm 813$, $p < 0.0001$) and 6.92% (obese/overweight: 7.80% vs. not obese/overweight: 6.47%, $p < 0.0001$) experiencing nonroutine disposition. Among patients diagnosed with PCOS and obesity/overweight, those who underwent any type of bariatric surgery had significantly shorter length of stay (2.21 ± 0.05 vs. 4.09 ± 0.07 , $p < 0.0001$), higher hospital charges ($\$66,023 \pm 2234$ vs. $\$43,059 \pm 1150$, $p < 0.0001$), and lower risk of nonroutine disposition (3.6% vs. 9.2%, $p < 0.0001$)

than those who did not. Of patients diagnosed with PCOS, 34 died while hospitalized (5.1 per 10,000; obese/overweight: 4.6 per 10,000; and not obese/overweight: 5.4 per 10,000), and of those, 2 (5.9%) corresponded to women diagnosed with PCOS and obesity/overweight who had undergone bariatric surgery.

Table 3 presents specific bariatric surgery type (RYGB, LSG, and LAGB) as a predictor of length of hospital stay, hospitalization charges, and disposition among obese/overweight women diagnosed with PCOS. Compared to RYGB, LSG and LAGB were associated, on average, with significantly shorter hospital stays, lower hospital charges, and fewer nonroutine disposition at discharge, after controlling for patient- and hospital-level characteristics.

Table 4 presents the association of PCOS status with bariatric surgery type, length of hospital stay, hospitalization charges, and non-routine disposition among women who underwent RYGB, LSG, or LAGB. Results suggested that PCOS and non-PCOS women experienced similar treatment selection as well as in-hospital outcomes after bariatric surgery, after controlling for confounders.

Discussion

In this retrospective cohort study using data on 52,668 hospital discharge records from the 1998 to 2011 NIS, we examined patient- and hospital-level characteristics as predictors of obesity/overweight among women diagnosed with PCOS as well as predictors of bariatric surgery utilization among women diagnosed with PCOS and obesity/overweight. Between 1998 and 2011, we found steadily increasing trends in obesity/overweight. Bariatric surgery, on the other hand, increased until 2005, and tapered off afterward. Published NIS-based studies that examined time trends in utilization of bariatric surgeries since the 1990s^{25,27} reported an initial rise

TABLE 1. CHARACTERISTICS OF HOSPITAL DISCHARGES FOR WOMEN, 18–49 YEARS OF AGE, DIAGNOSED WITH POLYCYSTIC OVARIAN SYNDROME ACCORDING TO OBESITY/OVERWEIGHT STATUS (N=52,057): 1998–2011
NATIONWIDE INPATIENT SAMPLE

	PCOS				
	Unweighted analyses			Weighted analyses	
	Overall N (%) ^b	Obese/ overweight—yes N (%) ^b	Obese/ overweight—no N (%) ^b	Proportion, cOR (95% CI)	aOR (95% CI) ^a
Overall	52,057 (100)	17,566 (100)	34,491 (100)		
Age (years)				<i>p</i> <0.0001	
18–19	1562 (3.00)	511 (2.91)	1051 (3.05)	0.31, Ref.	Ref.
20–24	6532 (12.55)	2168 (12.34)	4364 (12.65)	0.33, 1.08 (0.93–1.24)	1.07 (0.91–1.26)
25–29	12,160 (23.36)	3814 (21.71)	8346 (24.20)	0.32, 1.02 (0.88–1.18)	1.01 (0.86–1.18)
30–34	13,837 (26.58)	4444 (25.30)	9393 (27.23)	0.32, 1.03 (0.89–1.19)	1.03 (0.88–1.19)
35–39	9942 (19.10)	3473 (19.77)	6469 (18.76)	0.34, 1.15 (0.99–1.33)	1.09 (0.94–1.28)
40–44	5377 (10.33)	2069 (11.78)	3308 (9.59)	0.39, 1.39 (1.19–1.62)	1.26 (1.07–1.48)
45–49	2647 (5.08)	1087 (6.19)	1560 (4.52)	0.41, 1.51 (1.27–1.81)	1.23 (1.02–1.48)
Mean ± SEM	31.85 ± 0.054	32.33 ± 0.081	31.62 ± 0.062		
Race/ethnicity				<i>p</i> <0.0001	
White	30,501 (58.59)	10,473 (59.62)	20,028 (58.07)	0.34, Ref.	Ref.
African American	4331 (8.32)	1598 (9.10)	2733 (7.92)	0.37, 1.13 (1.03–1.25)	1.09 (0.99–1.19)
Hispanic	3383 (6.50)	1283 (7.30)	2100 (6.09)	0.38, 1.17 (1.05–1.29)	1.14 (1.03–1.27)
Other	2101 (4.04)	565 (3.22)	1536 (4.45)	0.26, 0.66 (0.56–0.79)	0.67 (0.57–0.79)
Unknown	11,741 (22.55)	3647 (20.76)	8094 (23.47)	0.30, 0.81 (0.73–0.90)	0.92 (0.83–1.01)
Charlson Comorbidity Index				<i>p</i> <0.0001	
0	35,241 (67.70)	9747 (55.49)	25,494 (73.91)	0.28, Ref.	Ref.
1	12,222 (23.48)	5597 (31.86)	6625 (19.21)	0.46, 2.19 (2.07–2.32)	2.06 (1.94–2.18)
2+	4594 (8.82)	2222 (12.65)	2372 (6.88)	0.48, 2.42 (2.22–2.64)	2.18 (1.99–2.38)
Year of admission				<i>p</i> <0.0001	
1998	908 (1.74)	131 (0.75)	777 (2.25)	0.15, Ref.	Ref.
1999	1142 (2.19)	155 (0.88)	987 (2.86)	0.13, 0.86 (0.63–1.17)	0.86 (0.64–1.17)
2000	1326 (2.55)	246 (1.40)	1080 (3.13)	0.19, 1.29 (0.96–1.74)	1.29 (0.96–1.74)
2001	1589 (3.05)	339 (1.93)	1250 (3.62)	0.22, 1.59 (1.20–2.10)	1.57 (1.19–2.07)
2002	2203 (4.23)	576 (3.28)	1627 (4.72)	0.27, 2.08 (1.57–2.75)	2.11 (1.59–2.78)
2003	2587 (4.97)	695 (3.96)	1892 (5.49)	0.29, 2.23 (1.68–2.96)	2.19 (1.66–2.90)
2004	3218 (6.18)	1034 (5.89)	2184 (6.33)	0.32, 2.67 (2.03–3.49)	2.57 (1.96–3.36)
2005	3590 (6.90)	1110 (6.32)	2480 (7.19)	0.32, 2.66 (2.04–3.49)	2.57 (1.97–3.35)
2006	4207 (8.08)	1316 (7.49)	2891 (8.38)	0.32, 2.67 (2.07–3.47)	2.55 (1.97–3.29)
2007	4742 (9.11)	1638 (9.32)	3104 (9.00)	0.34, 2.88 (2.24–3.70)	2.76 (2.15–3.55)
2008	5877 (11.29)	2120 (12.07)	3757 (10.89)	0.37, 3.26 (2.52–4.21)	3.11 (2.41–4.01)
2009	6090 (11.70)	2407 (13.70)	3683 (10.68)	0.38, 3.43 (2.66–4.41)	3.28 (2.55–4.21)
2010	6888 (13.23)	2758 (15.70)	4130 (11.97)	0.39, 3.67 (2.85–4.74)	3.43 (2.66–4.42)
2011	7690 (14.77)	3041 (17.31)	4649 (13.48)	0.39, 3.56 (2.77–4.57)	3.35 (2.61–4.28)
Discharge quarter				<i>p</i> =0.38	
1st Quarter	12,094 (23.23)	4013 (22.85)	8081 (23.43)	0.33, Ref.	Ref.
2nd Quarter	12,948 (24.87)	4402 (25.06)	8546 (24.78)	0.34, 1.05 (0.98–1.12)	1.07 (0.99–1.14)
3rd Quarter	13,454 (25.84)	4527 (25.77)	8927 (25.88)	0.33, 1.00 (0.94–1.07)	1.03 (0.96–1.09)
4th Quarter	13,561 (26.05)	4624 (26.32)	8937 (25.91)	0.34, 1.03 (0.97–1.10)	1.04 (0.98–1.11)
Weekend admission status				<i>p</i> <0.0001	
Monday-Friday	44,664 (85.80)	15,288 (87.03)	29,376 (85.17)	0.34, Ref.	Ref.
Saturday-Sunday	7393 (14.20)	2278 (12.97)	5115 (14.83)	0.30, 0.83 (0.78–0.90)	0.78 (0.72–0.84)
Primary payer				<i>p</i> <0.0001	
Medicare	3191 (6.13)	1383 (7.87)	1808 (5.24)	0.43, Ref.	Ref.
Medicaid	7564 (14.53)	2578 (14.68)	4986 (14.46)	0.34, 0.69 (0.62–0.79)	0.83 (0.73–0.94)
Private insurance	35,532 (68.26)	11,506 (65.50)	24,026 (69.66)	0.33, 0.64 (0.57–0.72)	0.82 (0.73–0.92)
Self-pay	3042 (5.84)	1192 (6.79)	1850 (5.36)	0.39, 0.84 (0.73–0.97)	1.07 (0.92–1.25)
No charge	291 (0.56)	109 (0.62)	182 (0.53)	0.35, 0.73 (0.54–0.98)	0.84 (0.62–1.13)
Other	2437 (4.68)	798 (4.54)	1639 (4.75)	0.32, 0.61 (0.51–0.75)	0.79 (0.66–0.94)

(continued)

TABLE 1. (CONTINUED)

	PCOS				
	Unweighted analyses			Weighted analyses	
	Overall N (%) ^b	Obese/ overweight—yes N (%) ^b	Obese/ overweight—no N (%) ^b	Proportion, cOR (95% CI)	aOR (95% CI) ^a
Hospital region				<i>p</i> =0.76	
Northeast	9081 (17.44)	3093 (17.61)	5988 (17.36)	0.34, Ref.	Ref.
Midwest	13,833 (26.57)	4756 (27.08)	9077 (26.32)	0.33, 0.94 (0.83–1.08)	1.09 (0.96–1.25)
South	18,936 (36.38)	6258 (35.63)	12,678 (36.76)	0.34, 1.00 (0.88–1.14)	1.09 (0.93–1.29)
West	10,207 (19.61)	3459 (19.69)	6748 (19.56)	0.34, 1.01 (0.88–1.14)	1.12 (0.95–1.32)
Hospital control				<i>p</i> =0.016	
Government or private	32,121 (61.70)	11,259 (64.10)	20,862 (60.49)	0.34, Ref.	Ref.
Government, nonfederal	3026 (5.81)	849 (4.83)	2177 (6.31)	0.29, 0.77 (0.67–0.89)	0.82 (0.68–0.99)
Private, not for profit	10,222 (19.64)	3260 (18.56)	6962 (20.18)	0.33, 0.93 (0.83–1.04)	0.94 (0.78–1.13)
Private, investor owned	4353 (8.36)	1513 (8.61)	2840 (8.23)	0.36, 1.07 (0.88–1.29)	1.09 (0.86–1.38)
Private	2335 (4.49)	685 (3.90)	1650 (4.78)	0.29, 0.78 (0.62–0.98)	0.99 (0.76–1.31)
Hospital teaching status/location				<i>p</i> =0.0014	
Rural	6677 (12.83)	1854 (10.55)	4823 (13.98)	0.29, Ref.	Ref.
Urban—nonteaching	21,143 (40.62)	7175 (40.85)	13,968 (40.50)	0.33, 1.24 (1.07–1.44)	1.15 (0.97–1.36)
Urban—teaching	24,237 (46.56)	8537 (48.60)	15,700 (45.52)	0.35, 1.31 (1.13–1.52)	1.15 (0.95–1.41)
Hospital bed size				<i>p</i> =0.88	
Small	6329 (12.16)	2199 (12.52)	4130 (11.97)	0.34, Ref.	Ref.
Medium	12,770 (24.53)	4296 (24.46)	8474 (24.57)	0.34, 0.97 (0.84–1.12)	0.99 (0.86–1.13)
Large	32,958 (63.31)	11,071 (63.03)	21,887 (63.46)	0.33, 0.97 (0.85–1.10)	0.99 (0.87–1.12)

^aFully adjusted logistic regression model, taking complex survey design into consideration.

^bUnweighted analyses with column percentages.

aOR, adjusted odds ratio; CI, confidence interval; cOR, crude odds ratio; PCOS, polycystic ovarian syndrome; SEM, standard error of the mean.

followed by a decline that may be attributed to hospital accreditation by the American College of Surgeons and the American Society of Metabolic and Bariatric Surgery, starting in 2004. This gave rise to Centers for Medicare and Medicaid Services issuing a National Coverage Determination mandating that bariatric surgeries be performed only at accredited centers.^{26,28}

While obesity/overweight diagnosis did not vary substantially until 40 years of age, bariatric surgery utilization among obese/overweight women increased at 20 years of age. Although African American women were more likely to be diagnosed with obesity/overweight, they were less likely to undergo bariatric surgery. Patients admitted on weekends were less likely to be diagnosed with obesity/overweight and to undergo bariatric surgeries. While Medicare recipients were more likely than others to be diagnosed with obesity/overweight, bariatric surgery was more frequently performed among patients with private insurance, self-pay, or other types of insurance. The high prevalence of obesity/overweight among Medicare recipients may be attributed to the presence of disabilities among those patients who are <50 years of age. Although no significant difference in obesity/overweight diagnosis by hospital region was noted, Northeastern hospitals were more likely than others to perform bariatric surgeries. Furthermore, urban hospitals were more likely than rural hospitals to admit obese/overweight patients and to perform bariatric surgeries. Obesity/overweight was increased among patients admitted to public,

nonfederal hospitals, whereas bariatric surgeries were more frequently performed in the context of private investor-owned hospitals. Disparities in the utilization of bariatric surgeries according to patient level (sex, age, race, income, health insurance, and comorbidities) and hospital level (region, urban-rural status, teaching status, and volume) were similarly reported by previously published studies that performed secondary analyses of the NIS data.^{24,26,29}

To our knowledge, this study is the first to examine bariatric surgeries among obese/overweight PCOS women using a nationally representative sample of hospitalized patients. Recently published studies have also used NIS data to examine utilization and outcomes of bariatric surgeries among special populations, including uncomplicated diabetes,¹⁷ celiac disease,¹⁸ HIV infection,³⁰ inflammatory bowel disease,^{20,31} hepatocellular carcinoma,³² non-alcoholic fatty liver disease,¹⁹ and acute pancreatitis.²¹ A study by Parker et al. analyzed 2012 NIS data from 186,605 women with obesity and singleton gestations, and found that a prior bariatric surgery was associated with increased risk of intrauterine growth restriction, with no impact on preeclampsia, intrauterine fetal demise, large-for-gestational age, postpartum hemorrhage, failed induction of labor, cesarean delivery, or operative vaginal delivery.³³ However, two systematic reviews found safety concerns to be, in general, lower among obese women of reproductive age who underwent bariatric surgery versus those who did not.³⁴ This is consistent with our results, which suggested that PCOS patients who had

TABLE 2. BARIATRIC SURGERY STATUS BY CHARACTERISTICS OF HOSPITAL DISCHARGES FOR WOMEN, 18–49 YEARS OF AGE, DIAGNOSED WITH POLYCYSTIC OVARIAN SYNDROME AND OBESE/OVERWEIGHT ($N=17,566$): 1998–2011 NATIONWIDE INPATIENT SAMPLE

	<i>Obese/overweight PCOS</i>				
	<i>Unweighted analyses</i>			<i>Weighted analyses</i>	
	<i>Overall N (%)^b</i>	<i>Bariatric surgery—yes N (%)^b</i>	<i>Bariatric surgery—no N (%)^b</i>	<i>Proportion, cOR (95% CI)</i>	<i>aOR (95% CI)^a</i>
Overall	17,566 (100)	4265 (100)	13,301 (100)		
Age (years)				$p=0.0009$	
18–19	511 (2.91)	83 (1.95)	428 (3.22)	0.17, Ref.	Ref.
20–24	2168 (12.34)	447 (10.48)	1721 (12.94)	0.21, 1.28 (0.93–1.75)	1.37 (0.98–1.92)
25–29	3814 (21.71)	917 (21.50)	2897 (21.78)	0.23, 1.47 (1.09–1.98)	1.49 (1.08–2.06)
30–34	4444 (25.30)	1096 (25.70)	3348 (25.17)	0.25, 1.61 (1.19–2.18)	1.54 (1.11–2.14)
35–39	3473 (19.77)	915 (21.45)	2558 (19.23)	0.26, 1.67 (1.24–2.26)	1.57 (1.13–2.18)
40–44	2069 (11.78)	529 (12.40)	1540 (11.58)	0.26, 1.66 (1.22–2.27)	1.58 (1.13–2.20)
45–49	1087 (6.19)	278 (6.52)	809 (6.08)	0.24, 1.55 (1.08–2.24)	1.48 (1.00–2.17)
Mean $\pm$ SEM	32.33 $\pm$ 0.081	32.74 $\pm$ 0.15	32.19 $\pm$ 0.091	$p=0.001$	
Race/ethnicity				$p=0.082$	
White	10,473 (59.62)	2677 (62.77)	7796 (58.61)	0.25, Ref.	Ref.
African American	1598 (9.10)	292 (6.85)	1306 (9.82)	0.18, 0.65 (0.53–0.80)	0.69 (0.57–0.84)
Hispanic	1283 (7.30)	306 (7.17)	977 (7.35)	0.24, 0.92 (0.70–1.19)	0.89 (0.69–1.16)
Other	565 (3.22)	169 (3.96)	396 (2.98)	0.28, 1.19 (0.79–1.78)	1.01 (0.69–1.47)
Unknown	3647 (20.76)	821 (19.25)	2,826 (21.25)	0.24, 0.95 (0.73–1.26)	1.22 (0.93–1.61)
Charlson Comorbidity Index				$p<0.0001$	
0	9747 (55.49)	2446 (57.35)	7301 (54.89)	0.25, Ref.	Ref.
1	5597 (31.86)	1484 (34.79)	4113 (30.92)	0.26, 1.07 (0.96–1.19)	1.17 (1.05–1.31)
2+	2222 (12.65)	335 (7.85)	1887 (14.19)	0.15, 0.55 (0.47–0.66)	0.63 (0.52–0.76)
Year of admission				$p=0.0002$	
1998	131 (0.75)	7 (0.16)	124 (0.93)	0.06, Ref.	Ref.
1999	155 (0.88)	10 (0.23)	145 (1.09)	0.08, 1.36 (0.36–5.09)	1.41 (0.36–5.45)
2000	246 (1.40)	26 (0.61)	220 (1.65)	0.12, 1.98 (0.57–6.81)	2.24 (0.63–7.96)
2001	339 (1.93)	50 (1.17)	289 (2.17)	0.14, 2.50 (0.73–8.63)	2.86 (0.80–10.23)
2002	576 (3.28)	139 (3.26)	437 (3.29)	0.24, 4.64 (1.45–14.87)	5.36 (1.63–17.66)
2003	695 (3.96)	191 (4.48)	504 (3.79)	0.28, 5.83 (1.85–18.36)	6.60 (2.05–21.32)
2004	1034 (5.89)	329 (7.71)	705 (5.30)	0.32, 7.04 (2.22–22.29)	7.95 (2.45–25.75)
2005	1110 (6.32)	313 (7.34)	797 (5.99)	0.32, 6.83 (2.21–21.14)	7.95 (2.52–25.11)
2006	1316 (7.49)	283 (6.64)	1033 (7.77)	0.22, 4.14 (1.34–12.80)	4.57 (1.44–14.51)
2007	1638 (9.32)	368 (8.63)	1270 (9.55)	0.20, 3.70 (1.17–11.73)	4.22 (1.31–13.65)
2008	2120 (12.07)	518 (12.15)	1602 (12.04)	0.26, 5.26 (1.70–16.25)	5.96 (1.89–18.79)
2009	2407 (13.70)	659 (15.45)	1748 (13.14)	0.27, 5.61 (1.83–17.21)	7.06 (2.24–22.21)
2010	2758 (15.70)	669 (15.69)	2089 (15.71)	0.23, 4.49 (1.45–13.92)	5.79 (1.82–18.43)
2011	3041 (17.31)	703 (16.48)	2338 (17.58)	0.22, 4.18 (1.34–12.97)	5.03 (1.58–15.99)
Discharge quarter				$p=0.53$	
1st Quarter	4013 (22.85)	941 (22.06)	3072 (23.10)	0.24, Ref.	Ref.
2nd Quarter	4402 (25.06)	1063 (24.92)	3339 (25.10)	0.25, 1.01 (0.89–1.15)	1.03 (0.90–1.18)
3rd Quarter	4527 (25.77)	1106 (25.93)	3421 (25.72)	0.23, 0.93 (0.83–1.05)	0.94 (0.83–1.07)
4th Quarter	4624 (26.32)	1155 (27.08)	3469 (26.08)	0.24, 0.99 (0.87–1.12)	1.02 (0.89–1.17)
Weekend admission status				$p<0.0001$	
Monday-Friday	15,288 (87.03)	4246 (99.55)	11,042 (83.02)	0.28, Ref.	Ref.
Saturday-Sunday	2278 (12.97)	19 (0.45)	2259 (16.98)	0.0066, 0.017 (0.0075–0.040)	0.018 (0.0079–0.043)
Primary payer				$p<0.0001$	
Medicare	1383 (7.87)	153 (3.59)	1230 (9.25)	0.097, Ref.	Ref.
Medicaid	2578 (14.68)	266 (6.24)	2312 (17.38)	0.11, 1.19 (0.88–1.62)	1.21 (0.89–1.64)
Private insurance	11,506 (65.50)	3406 (79.86)	8100 (60.90)	0.29, 3.95 (3.09–5.05)	3.77 (2.94–4.84)
Self-pay	1192 (6.79)	220 (5.16)	972 (7.31)	0.16, 1.81 (1.20–2.71)	2.22 (1.48–3.32)
No charge	109 (0.62)	9 (0.21)	100 (0.75)	0.029, 0.28 (0.069–1.19)	0.27 (0.068–1.07)
Other	798 (4.54)	211 (4.95)	587 (4.41)	0.24, 3.00 (2.07–4.35)	3.32 (2.24–4.91)

(continued)

TABLE 2. (CONTINUED)

<i>Obese/overweight PCOS</i>					
	<i>Unweighted analyses</i>			<i>Weighted analyses</i>	
	<i>Overall N (%)^b</i>	<i>Bariatric surgery—yes N (%)^b</i>	<i>Bariatric surgery—no N (%)^b</i>	<i>Proportion, cOR (95% CI)</i>	<i>aOR (95% CI)^a</i>
Hospital region				<i>p</i> =0.0023	
Northeast	3093 (17.61)	980 (22.98)	2113 (15.89)	0.32, Ref.	Ref.
Midwest	4756 (27.08)	1032 (24.20)	3724 (28.00)	0.21, 0.56 (0.39–0.78)	0.48 (0.34–0.67)
South	6258 (35.63)	1450 (34.00)	4808 (36.15)	0.21, 0.56 (0.39–0.79)	0.43 (0.28–0.66)
West	3459 (19.69)	803 (18.83)	2656 (19.97)	0.23, 0.65 (0.47–0.90)	0.45 (0.30–0.68)
Hospital control				<i>p</i> =0.011	
Government or private	11,259 (64.10)	2894 (67.85)	8365 (62.89)	0.26, Ref.	Ref.
Government, nonfederal	849 (4.83)	126 (2.95)	723 (5.44)	0.15, 0.51 (0.25–1.04)	1.35 (0.57–3.23)
Private, not for profit	3260 (18.56)	617 (14.47)	2643 (19.87)	0.19, 0.66 (0.47–0.95)	1.56 (0.88–2.75)
Private, investor owned	1513 (8.61)	543 (12.73)	970 (7.29)	0.32, 1.34 (0.78–2.31)	3.37 (1.71–6.65)
Private	685 (3.90)	85 (1.99)	600 (4.51)	0.14, 0.46 (0.23–0.92)	2.12 (0.84–5.34)
Hospital teaching status/location				<i>p</i> =0.0001	
Rural	1854 (10.55)	214 (5.02)	1640 (12.33)	0.13, Ref.	Ref.
Urban—nonteaching	7175 (40.85)	1728 (40.52)	5447 (40.95)	0.22, 1.97 (1.24–3.14)	2.13 (1.22–3.71)
Urban—teaching	8537 (48.60)	2323 (54.47)	6214 (46.72)	0.28, 2.68 (1.74–4.14)	4.07 (2.22–7.48)
Hospital bed size				<i>p</i> =0.55	
Small	2199 (12.52)	654 (15.33)	1545 (11.62)	0.27, Ref.	Ref.
Medium	4296 (24.46)	1036 (24.29)	3260 (24.51)	0.23, 0.79 (0.51–1.20)	0.84 (0.54–1.29)
Large	11,071 (63.03)	2575 (60.38)	8496 (63.87)	0.24, 0.86 (0.59–1.25)	0.97 (0.66–1.41)

^aFully adjusted logistic regression model, taking complex survey design into consideration.^bUnweighted analyses with column percentages.

TABLE 3. BARIATRIC SURGERY TYPE AS PREDICTOR OF LENGTH OF HOSPITAL STAY, HOSPITALIZATION CHARGES, AND NONROUTINE DISPOSITION AMONG WOMEN DIAGNOSED WITH POLYCYSTIC OVARIAN SYNDROME AND OBESE/OVERWEIGHT WHO UNDERWENT SPECIFIC BARIATRIC SURGERIES: 1998–2011 NATIONWIDE INPATIENT SAMPLE

	<i>Length of hospital stay^a (n = 3048)</i>				<i>Hospitalization charges^a (n = 3028)</i>				<i>Nonroutine disposition^a (n = 3047)</i>			
	<i>Mean</i>	<i>SE</i>	<i>β</i>	<i>95% CI</i>	<i>Mean</i>	<i>SE</i>	<i>β</i>	<i>95% CI</i>	<i>N</i>	<i>%</i>	<i>OR</i>	<i>95% CI</i>
Surgery type												
Roux-en-Y gastric bypass	2.22	0.052	Ref.	—	74,986	2858	Ref.	—	78	3.96	Ref.	—
Laparoscopic sleeve gastrectomy	1.47	0.091	−0.43	−0.54 to −0.32	74,857	8832	−0.059	−0.32 to 0.20	1	1.06	0.26	0.034 to 1.88
Laparoscopic adjustable gastric banding	1.04	0.022	−0.64	−0.69 to −0.58	57,155	3036	−0.23	−0.35 to −0.11	2	0.44	0.11	0.031 to 0.37
Surgery type												
Roux-en-Y gastric bypass	—	—	Ref.	—	—	—	Ref.	—	—	—	Ref.	—
Laparoscopic sleeve gastrectomy	—	—	−0.42	−0.53 to −0.32	—	—	−0.18	−0.36 to −0.01	—	—	0.20	0.03 to 1.30
Laparoscopic adjustable gastric banding	—	—	−0.64	−0.68 to −0.59	—	—	−0.22	−0.31 to −0.12	—	—	0.06	0.02 to 0.15

^aWeighted analyses; linear regression models of length of hospital stay and hospital charges used log_e-transformed outcomes.^bAdjusted for patient- and hospital-level characteristics.

OR, odds ratio; SE, standard error.

TABLE 4. ASSOCIATION OF POLYCYSTIC OVARIAN SYNDROME WITH BARIATRIC SURGERY TYPE, LENGTH OF HOSPITAL STAY, HOSPITALIZATION CHARGES, AND NONROUTINE DISPOSITION AMONG OBESE/OVERWEIGHT WOMEN WHO UNDERWENT SPECIFIC BARIATRIC SURGERIES: 1998–2011 NATIONWIDE INPATIENT SAMPLE

	<i>Overall</i> (<i>n</i> = 81,237)	<i>PCOS</i> (<i>n</i> = 3052)	<i>No PCOS</i> (<i>n</i> = 78,185)	<i>Unadjusted</i> <i>OR</i> (95% <i>CI</i>)	<i>Adjusted^a</i> <i>OR</i> (95% <i>CI</i>)
Surgery type (%)					
Roux-en-Y gastric bypass	75.7	75.5	75.7	Ref.	Ref.
Laparoscopic sleeve gastrectomy	3.6	4.4	3.6	1.22 (0.97–1.54)	0.98 (0.80–1.19)
Laparoscopic adjustable gastric banding	20.7	20.1	20.7	0.97 (0.83–1.13)	0.89 (0.77–1.03)
Length of hospital stay, <i>N</i>	81,237	3052	78,185		
Mean ± SEM	2.08 ± 0.03	1.95 ± 0.04	2.09 ± 0.03	0.86 (0.76–0.97)	0.98 (0.88–1.09)
Hospitalization charges, <i>N</i>	80,738	3032	77,706		
Mean ± SEM	66,253 ± 2169	71,418 ± 2496	66,063 ± 2177	1.34 (1.19–1.51)	0.93 (0.82–1.04)
Non-routine disposition (%), <i>N</i>	81,178	3051	78,127		
	3.0	3.1	3.0	1.03 (0.75–1.41)	1.15 (0.85–1.56)
Roux-en-Y gastric bypass (<i>n</i> = 62,896)					
Length of hospital stay, <i>N</i>	62,896	2380	60,516		
Mean ± SEM	2.37 ± .038	2.22 ± .052	2.37 ± .039	0.81 (0.67–0.96)	0.94 (0.82–1.09)
Hospitalization charges, <i>N</i>	62,496	2365	60,131		
Mean ± SEM	68,731 ± 2525	75,013 ± 2859	68,499 ± 2538	1.39 (1.22–1.59)	0.89 (0.78–1.014)
Nonroutine disposition (%), <i>N</i>	62,872	2379	60,493		
	3.6	3.9	3.6	1.11 (0.79–1.57)	1.27 (0.92–1.78)
Laparoscopic sleeve gastrectomy (<i>n</i> = 2804)					
Length of hospital stay, <i>N</i>	2804	125	2679		
Mean ± SEM	1.62 ± 0.074	1.46 ± 0.091	1.63 ± 0.075	0.77 (0.51–1.15)	0.66 (0.44–1.00)
Hospitalization charges, <i>N</i>	2803	125	2678		
Mean ± SEM	65,034 ± 5519	74,857 ± 8832	64,589 ± 53,918	1.41 (1.04–1.92)	1.08 (0.69–1.69)
Nonroutine disposition (%), <i>N</i>	2804	125	2679		
	1.9	1.1	1.9	0.53 (0.091–3.15)	0.92 (0.23–3.64)
Laparoscopic adjustable gastric banding (<i>n</i> = 15,537)					
Length of hospital stay, <i>N</i>	15,537	547	14,990		
Mean ± SEM	1.11 ± 0.017	1.04 ± 0.021	1.11 ± 0.017	0.72 (0.49–1.05)	0.88 (0.62–1.24)
Hospitalization charges, <i>N</i>	15,439	542	14,897		
Mean ± SEM	57,436 ± 2478	57,136 ± 3030	57,447 ± 2484	1.06 (0.82–1.37)	0.94 (0.72–1.22)
Nonroutine disposition (%), <i>N</i>	15,502	547	14,955		
	1.3	0.4	1.3	0.33 (0.088–1.27)	0.36 (0.095–1.34)

Weighted analyses; logistic regression models with length of hospital stay and hospital charges used log_e-transformed variables.

^aAdjusted for patient- and hospital-level characteristics.

obesity/overweight and underwent bariatric surgeries have shorter hospitalization and better disposition at discharge, although they incurred greater hospital charges than those who did not. Although we found a considerably lower in-hospital mortality rate among PCOS women than previously conducted research, our estimated mean length of stay, hospital charges, and nonroutine disposition rates were consistent with existing studies using NIS data.^{21,26,35}

Our study findings suggest that PCOS and non-PCOS women may experience similar in-hospital outcomes after RYGB, LSG, and LAGB. As expected, our results also suggested that LSG and LAGB exhibited shorter hospitalization, reduced hospital charges, and better disposition than RYGB. Previously conducted NIS-based studies that compared at least two of these techniques also found variability in terms of in-hospital outcomes.^{17,24,25} For instance, a recent study of uncomplicated diabetic patients by Baffoe et al. used the 2009–2014 NIS data and found that the chance of extended length of stay (>2 days) was less among patients who underwent LSG than those who underwent LAGB, control-

ling for confounders.¹⁷ Similarly, a study by Khan et al. using the 2008–2012 NIS data found that LAGB and LSG had the lowest rates of complications, in-hospital morbidity and mortality, and the shortest length of stay, whereas open bypass and duodenal switch had the highest rates of complications, in-hospital morbidity and mortality, and the longest hospitalizations.²⁵ A recently conducted systematic review of the literature identified six small retrospective cohort studies that were relevant to bariatric surgeries among PCOS patients, suggesting postoperative conception rates of 33%–100%, with improvements in menstrual irregularities, hormonal abnormalities, and hirsutism.¹⁶

Our study findings should be interpreted with caution and in light of several limitations. First, the NIS is an administrative database that originates from hospital discharge records, which are often restricted in scope, completeness, and accuracy. For instance, detailed information pertaining to reason for hospital admission, laboratory tests, and medications are often missing. Second, data clustering as a result of patient readmission to one of the participating hospitals

cannot be ascertained in the absence of unique patient identifiers. Third, complete subject analysis was performed with the potential for selection bias because of missing exposure, outcome, and/or covariate data. Fourth, eligibility criteria and many of the study variables were defined on the basis of previously reported ICD-9-CM codes, potentially leading to misclassification bias. In particular, the prevalence of obesity/overweight is likely underestimated when based on ICD-9-CM codes. Furthermore, PCOS diagnostic criteria may differ according to participating hospital and can vary over time. A substantial proportion of patients may not undergo a comprehensive metabolic workup before undergoing bariatric surgery, potentially leading to missed PCOS diagnosis as well as contamination of non-PCOS controls with PCOS patients. On the other hand, women identified as having PCOS through ICD-9-CM codes could represent a more severe phenotype and the fact that they had comparable operative outcomes to those not identified as having PCOS is interesting, given the higher risk of complications in the context of PCOS. For instance, insulin resistance, hyperglycemia, and androgen excess, which are highly prevalent among women affected by PCOS, are known contributors to venous thromboembolism and impaired wound healing risks. Fifth, adjusted measures of association may be biased due to unmeasured confounding in the context of an observational design. Sixth, the study design does not allow for the longitudinal examination of outcomes beyond hospitalization or the establishment of a temporal sequence of events, with the exception of discharge-related outcomes, for example, length of hospital stay, hospital charges, and non-routine disposition, which are known to have occurred following diagnosis and procedures. It is worth noting that rare outcomes such as specific complications and in-hospital death could not be examined in relationship to bariatric surgery due to sample size limitations. Finally, the results of this study can only be generalized to hospitalized PCOS patients, whose characteristics may differ from those who sought outpatient care.

In conclusion, the prevalence of obesity/overweight ($\approx 34\%$) among hospitalized women diagnosed with PCOS and of bariatric surgery ($\approx 24\%$) among hospitalized women diagnosed with PCOS and obesity/overweight varied by patient- and hospital-level characteristics. Moreover, LSG and LAGB resulted in improved outcomes among obese/overweight PCOS patients, compared to RYGB. Treatment selection and outcomes did not differ between PCOS and non-PCOS patients with an obesity/overweight diagnosis and who underwent specific bariatric surgeries. Further research is needed to examine health care disparities in the context of PCOS, obesity/overweight, and bariatric surgery. In particular, further comparative studies are needed to establish the risk-benefit ratio of bariatric surgeries among obese/overweight women diagnosed with PCOS, taking into account short-term and long-term outcomes, including more relevant endpoints focused on weight loss, improvement in PCOS symptoms, and fertility.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of Fort Belvoir Community Hospital, the Defense Health Agency, the Department of Defense, or the U.S. Government.

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