

Trends in Bariatric Surgical Procedures

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MORBID OBESITY IS AN increasing health problem in the United States. In 2002, 5.1% of US adults had a body mass index (BMI) higher than 40.¹ The prevalence of individuals with a BMI higher than 40 quadrupled from 1:200 in 1986 to 1:50 in 2000; the prevalence of individuals with a BMI higher than 50 quintupled from 1:2000 to 1:400.² Morbid obesity is associated with adverse health conditions and early mortality,³⁻⁶ and causes psychosocial and quality of life detriments.⁷⁻⁹ Livingston and Ko¹⁰ found significantly higher proportions for black race, lower education and income levels, and reliance on Medicaid among morbidly obese individuals in the United States. The increasing prevalence and associated sociodemographic disparities of morbid obesity are serious public health concerns.

In 1991, a National Institutes of Health Consensus Statement established guidelines for gastric bypass surgery and vertical banded gastroplasty for the treatment of morbid obesity (BMI of 35-40 with comorbidities or BMI >40).¹¹ Bariatric surgery remains the only durable option for weight loss in the morbidly obese.¹² However, bariatric surgery has changed dramatically since 1991 due to the increase in the prevalence of morbid obesity, the

See also pp 1903, 1918, 1957, 1960, and Patient Page.

Context The increasing prevalence and associated sociodemographic disparities of morbid obesity are serious public health concerns. Bariatric surgical procedures provide greater and more durable weight reduction than behavioral and pharmacological interventions for morbid obesity.

Objective To examine trends for elective bariatric surgical procedures, patient characteristics, and in-hospital complications from 1998 to 2003 in the United States.

Design, Setting, and Patients The Nationwide Inpatient Sample was used to identify bariatric surgery admissions from 1998-2002 (with preliminary data for 12 states from 2003) using *International Classification of Diseases, Ninth Revision*, codes for foregut surgery with a confirmatory diagnosis of obesity or by diagnosis related group code for obesity surgery. Annual estimates and trends were determined for procedures, patient characteristics, and adjusted complication rates.

Main Outcome Measures Trends in bariatric surgical procedures, patient characteristics, and complications.

Results The estimated number of bariatric surgical procedures increased from 13 365 in 1998 to 72 177 in 2002 ($P < .001$). Based on preliminary state-level data (1998-2003), the number of bariatric surgical procedures is projected to be 102 794 in 2003. Gastric bypass procedures accounted for more than 80% of all bariatric surgical procedures. From 1998 to 2002, there were upward trends in the proportion of females (81% to 84%; $P = .003$), privately insured patients (75% to 83%; $P = .001$), patients from ZIP code areas with highest annual household income (32% to 60%, $P < .001$), and patients aged 50 to 64 years (15% to 24%; $P < .001$). Length of stay decreased from 4.5 days in 1998 to 3.3 days in 2002 ($P < .001$). The adjusted in-hospital mortality rate ranged from 0.1% to 0.2%. The rates of unexpected reoperations for surgical complications ranged from 6% to 9% and pulmonary complications ranged from 4% to 7%. Rates of other in-hospital complications were low.

Conclusions These findings suggest that use of bariatric surgical procedures increased substantially from 1998 to 2003, while rates of in-hospital complications were stable and length of stay decreased. However, disparities in the use of these procedures, with disproportionate and increasing use among women, those with private insurance, and those in wealthier ZIP code areas should be explored further.

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advent of new procedures, and growing demand for surgery.¹³⁻¹⁵

Pope et al¹⁶ reported that total bariatric surgical procedures in the United States increased from 4925 in 1990 to 12 541 in 1997 and recently reported a continued increase to approximately 41 000 procedures in 2000.¹⁷ The American Society for Bariatric Surgery estimates that its members performed 63 000 bariatric surgical procedures nationwide in 2002, suggesting

that growth in bariatric procedures has been much greater in recent years.¹⁴

In this study, we examined recent national population-based trends in bariatric surgical procedures, patient characteristics, and in-hospital com-

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plications. In particular, we wanted to determine trends in newer techniques, in patient sociodemographic characteristics and comorbidities, and in surgical complications due to these procedural and patient population changes.

METHODS

We used the Nationwide Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project. It is the largest all-payer inpatient database in the United States. The NIS represents a 20% stratified sample of inpatient admissions to acute care hospitals nationwide (excludes federal and prison hospitals). Stratification is based on hospital region, urban/rural location, teaching status, number of beds, and ownership. Sampling weights are provided for accurate calculations based on the complex survey design. We obtained data from the most recent years available (1998 to 2002). Preliminary data were available for 2003 for some states via the Healthcare Cost and Utilization Project online query system. The NIS is publicly available and contains no personal identifying information; therefore, this study was exempt from institutional review board approval.

The *International Classification of Diseases, Ninth Revision (ICD-9)*,¹⁸ coding system does not have specific codes for all procedures currently performed for weight loss. We consulted previous studies and the Centers for Medicare & Medicaid Services' billing guidelines to develop a thorough list of ICD-9 codes to identify bariatric procedures.^{10,16,17,19-24} We relied on both a procedure code(s) for foregut surgery (43.0-44.99, 45.50-45.91) and a confirmatory diagnosis code for obesity (278.00-278.8) or a diagnosis related group code for obesity surgery (288). We excluded observations that were unlikely for elective weight-loss procedures based on diagnosis codes for gastrointestinal tract neoplasm (150.0-159.9), inflammatory bowel disease (555.0-556.9), or noninfectious colitis (557.0-558.9), and emergent admission codes (admission-type variable = emergent or urgent and/or

admission-source variable = emergency department or other hospital).

In the ICD-9, there is no code for laparoscopic bariatric surgery, so we explored whether the code for laparoscopy (54.21) would capture laparoscopic procedures. However, too few cases were identified to be plausible; therefore, we did not analyze laparoscopy further. Procedures were grouped by codes into 5 categories: gastric bypass, gastroplasty (vertical banded gastroplasty and adjustable gastric banding), malabsorptive (duodenal switch, biliopancreatic diversion, and isolated intestinal bypass), gastrectomy (all types of partial gastrectomies), and other (nonspecified gastric procedures and gastric bubble insertion) (TABLE 1).

Patient data included age, race, sex, and type of insurance. Average annual household income in the patient's ZIP code of residence (adjusted for inflation based on projections of the 1990 census; hereafter referred to as ZIP code level income) was reported in the NIS in 4 strata: less than \$24 999, \$25 000 to \$34 999, \$35 000 to \$44 999, and more than \$45 000. Based on 15 diagnosis codes (ICD-9) included in the data, we calculated a comorbidity index using the Deyo adaptation²⁵ of the Charlson Weighted Index of Comorbidity, a validated measure for use with administrative data that correlates with in-hospital morbidity and mortality.

Each state participating in the Healthcare Cost and Utilization Project had its own race classification schema or systematically did not report race. The Healthcare Cost and Utilization Project then created a uniform race variable, the categories of which were used for our data analysis. We attempted to analyze data to explore our hypothesis that racial disparities exist in the receipt of bariatric surgery. Unfortunately, due to the large amount of missing race data (21%-34%), this was not possible. However, for the purposes of multivariable analyses, race was included as an independent variable with missing race used as a separate category.

After reviewing recent studies,²⁶⁻³⁶ we classified complications that occurred

during admissions for a bariatric surgical procedure by codes into 2 categories: technical and systemic. Technical complications included unexpected reoperations for surgical complications, splenic injury, hemorrhage, anastomotic leaks, and wound complications. Systemic complications included respiratory tract, cardiac, neurological, thromboembolic, genitourinary tract, and multisystem (shock) complications. Mortality was available directly from the data set (Table 1).

Our primary outcomes of interest were types of bariatric procedures, patient characteristics, in-hospital complications, and length of stay. In our statistical analysis, we calculated frequencies of these outcomes for each year and determined if there were any trends in outcomes from 1998 to 2002. The complex survey design of the NIS prohibited conducting these analyses in a single step because sampling weights are changed annually to reflect increases in state participation. Collapsing multiyear data with varying sampling weights into a single data set results in invalid annual point and variance estimates and consequently invalid tests for trends across years.

Therefore, we first determined the frequency of each outcome for each year separately. We used sampling weights, strata, and primary sampling units unique to each year of the data to produce statistically valid point estimates and variances using the Taylor expansion method.³⁷ Point estimates and variances for complications were adjusted for patient age, race, sex, Charlson Index, type of insurance, and ZIP code level income using multiple logistic regression with SAS software version 9.1 (SAS Institute Inc, Cary, NC).

A simple test for trend based on point estimates alone ignores the fact that each estimate has an associated variance reflecting its sampling weight in the survey design. To analyze trends using the annual point estimates and variances previously calculated, we wrote a program using STATA software version 8 (STATA Corp, College Station, Tex) to perform the Cochran-

Armitage test for trend³⁸ across all 5 years of data. To achieve statistical significance, the test required both the point estimates and associated variances for the outcomes of interest to display a consistent linear relationship over time.

Calculating this test for trend was more complicated when examining trends in adjusted complication rates because of simultaneous trends in patient characteristics. Therefore, after determining the annual adjusted complication rates based on each year's case mix, we standardized complication rates to the 1998 patient characteristic modal values. Point estimates and variances of these standardized rates were then used to perform a valid test for trend. Trend tests were considered statistically significant at $P < .05$.

Although the NIS varies its sampling design annually so that data are nationally representative despite increasing state participation each year, we were concerned that trends may have been influenced by factors unique to states new to the NIS from 1998 to 2002. We repeated all estimates and statistical tests using data from 22 states that were continuously in the NIS from 1998 to 2002. No significant differences were found. The results presented herein include all states in the NIS.

The entire 2003 NIS data have not been released yet, but some state-level 2003 data are available online (<http://www.ahrq.gov/hcupnet.asp>). Using Healthcare Cost and Utilization Project online query system, we obtained estimates of the total number of procedures as well as patient age, sex, and type of insurance for 12 states (Arizona, Colorado, Florida, Hawaii, Iowa, Massachusetts, New Jersey, New York, Oregon, South Carolina, Utah, Washington) that were continuously in the NIS from 1998 through 2003. These data (hereafter referred to as state-level data) allowed us to track the number of procedures and trends in age, sex, and type of insurance in these states through 2003 and to project a national total for 2003.

Table 1. International Classification of Diseases, Ninth Revision (ICD-9), Procedure and Diagnosis Codes Used to Determine Surgical Procedure Categories and Complications

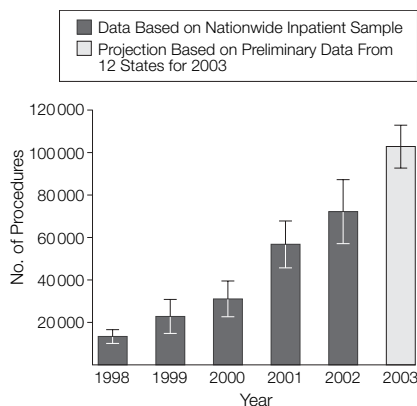
	ICD-9 Code
Procedure Category	
Gastric bypass	
High or "Mason" gastric bypass	44.31
Gastroenterostomy not elsewhere classified	44.39
Gastroplasty*	44.69
Malabsorptive	
Duodenal switch	
Sleeve gastrectomy	43.89
Small bowel to small bowel anastomosis	45.50
Small bowel segment isolation	45.51
Intestine to intestine anastomosis not otherwise specified	45.90
Intestinal isolation not otherwise specified	45.91
Biliopancreatic diversion	
Partial gastrectomy with jejunal anastomosis	43.7
Small bowel to small bowel anastomosis	45.50
Small bowel segment isolation	45.51
Intestine to intestine anastomosis not otherwise specified	45.90
Intestinal isolation not otherwise specified	45.91
Isolated intestinal bypass	
Small bowel to small bowel anastomosis	45.50
Small bowel segment isolation	45.51
Intestine to intestine anastomosis not otherwise specified	45.90
Intestinal isolation not otherwise specified	45.91
Gastrectomy	
Sleeve	43.89
Proximal	43.5
Distal	43.6
Other	
Gastric bubble insertion	44.93
Gastric operation not elsewhere classified	44.99
Type of Complication	
Technical	
Unexpected reoperations for surgical complications	
Wound dehiscence	54.61
Lysis of adhesions	54.51, 54.59
Removal of foreign body	54.92
Laparotomy	54.12
Splenic	
Injury	41.2
Partial or complete splenectomy	41.43, 41.5
Hemorrhagic	
Intraoperative hemorrhage	998.11
Postoperative hematoma	998.12
Blood transfusion	99.04, 99.09
Anastomotic	
Leak	998.6
Percutaneous abdominal drainage	54.91
Wound	
Infection	998.5, 998.51, 998.59
Seroma	998.13
Dehiscence	998.3
Obstruction	
Small bowel obstruction	560.0-560.9

(Continued)

Table 1. International Classification of Diseases, Ninth Revision (ICD-9), Procedure and Diagnosis Codes Used to Determine Surgical Procedure Categories and Complications (cont)

	ICD-9 Code
Systemic	
Pulmonary	
Respiratory tract complications	997.3
Acute bacterial pneumonia	481, 482.0-482.9, 485, 486
Acute respiratory failure	518.81
Tracheotomy	31.1, 31.29
Cardiac	
Complications	997.1
Acute myocardial infarction	410.0-410.9
Neurological	
Central nervous system complications	997.01-997.03
Acute cerebrovascular accident	431.00-431.91, 433.00-433.91, 434.00-434.91, 436, 437.1
Genitourinary tract	
Urinary tract complications	997.5
Acute renal failure	584.1-584.9
Acute dialysis	38.95
Insertion of short-term dialysis catheter	39.95
Thromboembolic	
Acute pulmonary embolism	415.1, 415.11, 415.19
Acute deep venous thrombosis	453.8, 453.9
Shock	
Postoperative	998.0

*Includes vertical banded gastroplasty and adjustable gastric banding.

Figure. National Trends in Annual Numbers of Bariatric Procedures, 1998-2003

Error bars indicate 95% confidence intervals.

RESULTS

The estimated number of bariatric surgical procedures increased from 13 365 in 1998 to 72 177 in 2002 ($P < .001$). Based on state-level data, this number is projected to be 102 794 in 2003 (FIGURE). Gastric bypass was the most commonly performed bariatric surgical procedure, accounting for 80% to 90% of all procedures during the study

period (TABLE 2). The proportion of gastroplasty procedures decreased from 25% in 1998 to 7% in 2002 ($P = .01$). Proportions of other procedures did not change significantly although absolute numbers increased.

Trends in patient characteristics appear in TABLE 3. Mean (SD) age increased from 39.6 (0.28) to 41.7 (0.21) years ($P < .001$), with an increase in the proportion of patients aged 50 to 64 years and a decrease in the proportion of patients aged 18 to 49 years. The proportion of adolescent patients (<18 years) was low and the proportion of elderly patients (>64 years) was stable. Between 1998 and 2003, state-level data showed an upward trend in the proportion of patients aged 45 to 64 years from 36% to 42% ($P = .03$; data not shown). The majority of patients were female nationally and in state-level data; nationwide the proportion of female patients increased from 81% in 1998 to 84% in 2002 ($P = .003$). Based on the Charlson Index, the proportion of patients without comorbidities decreased from 71% to 64% ($P = .001$). The proportion of patients with only 1 co-

morbidity increased from 23% to 29% ($P < .001$), but there were no changes in the proportion of patients with more than 1 comorbidity.

The proportion of patients with the highest ZIP code level income (>\$44 999 per year) increased from 32% to 60% ($P < .001$). Proportions of all other ZIP code level income groups decreased. The proportion of patients with private insurance increased from 75% to 83% ($P = .001$), while proportions of patients with Medicare and Medicaid decreased from 9% to 6% ($P = .003$) and from 7% to 5% ($P = .05$), respectively. State-level data showed the proportion of Medicaid patients declined from 10% to 7% between 1998 and 2003 ($P = .03$; data not shown) and the proportion of privately insured patients increased from 60% to 77% ($P = .04$; data not shown). The proportion of self-pay patients was stable.

Trends in adjusted and standardized in-hospital complications appear in TABLE 4. The standardized in-hospital mortality rate was stable between 0.1% and 0.2%. Standardized mean length of stay decreased from 4.5 days to 3.3 days ($P < .001$). There were no trends in technical complications, which occurred in 1% to 2% of admissions. Standardized rates of unexpected reoperations for surgical complications during the same admission ranged from 6% to 9%. The most frequent systemic complications were pulmonary and occurred in 4% to 7% of admissions. Rates of other complications were low and stable.

COMMENT

These data suggest that the estimated number of bariatric surgical procedures has increased markedly from 13 365 in 1998 to a projected 102 794 in 2003. Recent growth was substantially higher than that previously reported.^{16,17,21}

Encinosa et al³⁹ recently analyzed the costs associated with this increase in bariatric procedures and found increasing costs despite decreasing lengths of stay and fewer complications. If our observed rate of growth continues, there

will be approximately 130 000 bariatric procedures in 2005 and as many as 218 000 in 2010. The cost to the US health care system will be substantial. However, in the absence of a nonsurgical option for morbid obesity, our findings regarding in-hospital safety of

bariatric surgery are promising while our findings regarding worsening sociodemographic disparities are worrisome.

Similar to previous studies,^{16,17,21} we found gastric bypass to be the predominant procedure. Because adjustable gas-

tric banding was approved in the United States in 2001 and there was no code to separate it from vertical banded gastroplasty, we had expected an increase in gastroplasty procedures in 2001; instead, the proportion of gastroplasty procedures decreased during this period.

Table 2. Types of Bariatric Surgical Procedures Performed in the United States From 1998 to 2002 Based on Data From the Nationwide Inpatient Sample

Procedure Type	No. (%) of Procedures					P Value for Trend*
	1998	1999	2000	2001	2002	
Gastric bypass	10 675 (79.9)	20 421 (89.5)	27 497 (88.5)	48 507 (85.4)	63 538 (88.0)	.27
Gastroplasty†	3295 (24.7)	2097 (9.2)	4357 (14.0)	6247 (11.0)	5369 (7.4)	.01
Malabsorptive‡	990 (7.4)	1277 (5.6)	3684 (11.9)	4732 (8.3)	7495 (10.4)	.54
Gastrectomy§	258 (1.9)	721 (3.2)	495 (1.6)	2186 (3.8)	3082 (4.3)	.30
Other	43 (0.3)	31 (0.1)	70 (0.2)	303 (0.5)	1446 (1.9)	.13
Total No. of procedures¶	13 365	22 809	31 082	56 781	72 177	<.001

*In the proportion of total procedures.

†Includes vertical banded gastroplasty and adjustable gastric banding.

‡Includes duodenal switch, biliopancreatic diversion, and isolated intestinal bypass.

§Includes sleeve gastrectomy and any isolated partial gastrectomy.

||Includes gastric bubble insertion and nonspecified stomach procedures.

¶The numbers in the columns do not add up because they are survey weighted estimates.

Table 3. Characteristics of Patients Undergoing Elective Bariatric Surgical Procedures From 1998 to 2002 Based on Data From the Nationwide Inpatient Sample

	No. (%) of Patients*					P Value for Trend†
	1998 (n = 13 365)	1999 (n = 22 809)	2000 (n = 31 082)	2001 (n = 56 781)	2002 (n = 72 177)	
Age, mean (SD), y	39.6 (0.28)	41.5 (0.31)	40.8 (0.28)	40.9 (0.17)	41.7 (0.21)	<.001
Age categories, y						
<18	52 (0.4)	141 (0.6)	119 (0.4)	196 (0.4)	195 (0.3)	.09
18-34	4321 (32.3)	6052 (26.5)	8932 (28.7)	16 312 (28.7)	19 488 (27.0)	.007
35-49	6832 (51.1)	11 301 (49.6)	15 574 (50.1)	27 819 (49.0)	34 732 (48.1)	.01
50-64	2032 (15.2)	5029 (22.0)	6240 (20.0)	12 085 (21.3)	17 055 (23.6)	<.001
>64	127 (1.0)	286 (1.3)	217 (0.7)	368 (0.6)	706 (1.0)	.29
Women	10 782 (81.3)	18 595 (81.6)	26 493 (85.2)	47 714 (84.0)	60 671 (84.1)	.003
Annual income‡						
<\$24 999	605 (4.5)	826 (3.6)	1504 (4.8)	1715 (3.0)	1411 (2.0)	<.001
\$25 000 to \$34 999	3741 (28.0)	6267 (27.5)	7031 (22.6)	11 046 (19.5)	9844 (13.6)	<.001
\$35 000 to \$44 999	4253 (31.8)	7162 (31.4)	8326 (26.8)	13 771 (24.3)	16 122 (22.3)	<.001
≥\$45 000	4269 (31.9)	7858 (34.5)	13 583 (43.7)	29 638 (52.2)	43 055 (59.7)	<.001
Type of insurance						
Private§	10 061 (75.3)	17 135 (75.1)	25 043 (80.6)	46 893 (82.6)	59 835 (82.9)	.001
Medicare	1160 (8.7)	1975 (8.7)	1986 (6.4)	3243 (5.7)	4280 (5.9)	.003
Medicaid	949 (7.1)	1530 (6.7)	2184 (7.0)	2744 (4.8)	3433 (4.8)	.05
Self-pay	721 (5.4)	1450 (6.4)	1152 (3.7)	1866 (3.3)	2550 (3.5)	.06
Other	398 (3.0)	389 (1.7)	639 (2.0)	1472 (2.6)	1981 (2.7)	.87
Charlson Index						
None	9469 (70.8)	15 228 (66.8)	21 292 (68.5)	37 980 (66.9)	46 329 (64.2)	.001
1	3101 (23.2)	5980 (26.2)	7990 (25.7)	15 390 (27.1)	20 644 (28.6)	<.001
2	605 (4.5)	1285 (5.6)	1480 (4.8)	2791 (4.9)	4198 (5.8)	.16
>2	190 (1.4)	316 (1.4)	319 (1.0)	620 (1.1)	1005 (1.4)	.53

*Unless otherwise indicated.

†In the proportion of patients.

‡Annual household income based on patient's ZIP code of residence as reported by the Nationwide Inpatient Sample.

§Includes fee-for-service and health maintenance organizations.

||Using the Deyo adaptation²⁵ of the Charlson Index, which is designed for use with administrative data.

National studies previously examining gastric bypass and gastroplasty procedures found trends toward increasing proportions of gastric bypass.^{16,17} However, when we measured malabsorptive procedures and isolated gastrectomies, the proportion of gastric bypass procedures remained stable, suggesting that newer procedures were filling the gap between gastric bypass and gastroplasty from 1998 to 2002. We are aware of only 1 previous national study that also attempted to capture malabsorptive procedures²¹; however, that study did not describe trends in their proportions, which we found to be stable.

Patients undergoing bariatric surgical procedures were overwhelmingly female and the trend continued to increase during our study period. This is similar to findings in Wisconsin and North Carolina that rates of women undergoing bariatric surgery in the late 1990s to 2001 far outpaced those of men.^{23,24} Using cross-sectional data from 2000, Livingston and Ko¹⁰ found that 36% of US adults meeting current BMI criteria for bariatric surgery were male.

However, fewer than 20% of patients during our study period were male. Trus et al¹⁷ did not observe sex-based trends in bariatric surgery use between 1990 and 2000. This suggests that our observation is due to increases in the proportion of female patients since 2000 and may be attributable to a greater popularity of newer techniques among women.

Despite controversy over bariatric surgery for adolescent and elderly patients, each accounted for a small and stable proportion of patients. Overall, we demonstrated a shift toward higher risk patients in terms of both older age and higher comorbidities. Individuals aged 50 to 64 years were increasingly likely to undergo surgery during our study period. Other investigators^{17,22,40} have found a trend toward increasing average age of bariatric surgery patients; our results suggest this is due to increases among the oldest age group (50-64 years). We also found that patients were increasingly likely to have at least 1 comorbidity in the Charlson Index, an observation previously made in the data from a single state.⁴⁰

Bariatric surgery is not a regulated or credentialed surgical subspecialty. With the expanding pool of prospective patients and profitability of bariatric surgical procedures,¹⁴ surgeons and hospitals have been offering weight loss surgeries without accurate methods of tracking surgeons, procedural volume, patient characteristics, and post-operative complications.

Despite a shift toward higher risk patients, we did not find increases in in-hospital morbidity or mortality. We had anticipated that complication rates might increase as surgeons and hospitals operated at rates exceeding the learning curve for bariatric surgical procedures. Bariatric surgery is elective, and morbid obesity, despite associated adverse medical and social consequences, is not an immediate surgical indication. Therefore, even small increases in complication rates would have been clinically significant. Although rates of unexpected reoperations for surgical complications were substantial (7%-9%), mortality and rates of other technical and systemic complications were low and remained stable.

Table 4. In-Hospital Complications After Elective Bariatric Surgical Procedures From 1998 to 2002 Based on Data From the Nationwide Inpatient Sample

Type of Complication	1998		1999		2000		2001		2002		P Value for Trend‡
	AR*	SR†	AR*	SR†	AR*	SR†	AR*	SR†	AR*	SR†	
Mortality, %	1.0	0.2	0.5	0.2	0.1	0.1	<0.1	0.1	<0.1	0.1	.49
Length of stay, mean, d	4.9	4.5	4.6	4.1	4.2	3.9	4.0	3.6	3.8	3.3	<.001
Technical, %											
Unexpected reoperation for surgical complications	7.6	7.2	9.2	9.0	7.2	5.6	8.0	6.4	7.4	6.5	.34
Hemorrhagic	2.2	1.2	1.8	1.8	2.1	1.4	2.3	2.1	2.3	1.8	.28
Obstruction	1.7	2.0	1.7	1.9	1.4	1.3	2.3	1.5	1.4	1.1	.11
Wound	1.7	0.9	2.0	1.8	1.5	1.0	1.4	1.0	0.1	0.6	.12
Splenic	0.1	0.8	1.1	1.1	0.1	0.5	0.1	0.7	<0.1	0.4	.26
Anastomotic	0.1	0.2	<0.1	0.4	0.1	0.2	<0.1	0.2	<0.1	0.2	.87
Systemic, %											
Pulmonary	6.9	6.6	4.1	2.6	3.8	3.1	3.8	2.3	3.7	2.7	.08
Genitourinary tract	2.1	1.7	1.7	1.1	1.3	0.7	1.3	0.7	1.0	0.4	.003
Cardiac	1.4	1.3	1.4	1.3	1.0	0.4	1.2	0.9	1.1	0.9	.31
Neurological	0.2	0.2	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	.65
Thromboembolic	0.1	0.4	0.1	0.4	<0.1	0.1	<0.1	0.3	<0.1	0.3	.39
Shock	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	.59

Abbreviations: AR, adjusted rate; SR, standardized rate.

*Adjusted for patient age, race, sex, type of insurance, annual household income based on patient's ZIP code of residence, and Deyo adaptation²⁵ of the Charlson Index.

†Linear prediction of outcome adjusted for 1998 modal frequencies for age, race, sex, type of insurance, annual household income based on patient's ZIP code of residence, and

Deyo adaptation²⁵ of the Charlson Index to account for concurrent trends in patient case mix from 1998 to 2002.

‡Based on 1998 SR.

or improved during our study period. We did, however, find a decrease in length of stay. Because our study was based on in-hospital data, it is possible that some complications were not measured due to earlier discharge.

Although we could not assess racial trends, we did find evidence suggesting increasing socioeconomic disparities based on insurance status and ZIP code level income. Zhang and Wang⁴¹ had previously identified an inverse relationship between socioeconomic status and obesity. We found the opposite relationship between socioeconomic status and bariatric surgery use. Fewer than 5% of patients lived in ZIP code areas with average household incomes of less than \$25 000 per year, and this proportion was decreasing. Meanwhile, the proportion of patients who lived in ZIP code areas with average household incomes of more than \$44 999 per year increased to 60% in 2002.

Parallel trends were noted based on type of insurance. In both national and state-level data, the overwhelming majority of patients had private insurance and this proportion increased. In contrast, the proportion of Medicaid patients made up less than 10% of the patient population and this proportion was decreasing. These trends toward patients in higher socioeconomic groups based on ZIP code level income and type of insurance were in contrast to Livingston and Ko's findings that 28% of morbidly obese US adults in 2000 earned less than \$20 000 per year and that 12% were in the Medicaid program.¹⁰ It is possible that these disparities are the result of overuse of bariatric surgery among higher socioeconomic groups rather than underuse among lower socioeconomic groups. However, our finding that the socioeconomic profile of bariatric surgery patients increasingly did not reflect the socioeconomic profile of individuals with morbid obesity requires further study.

Our study has several important limitations. First, our results are estimates based on a large, complex survey sample. In the absence of a national bariatric sur-

gery registry, administrative data are the only source for national population-based trends in bariatric surgery and the NIS represents the best available data source given its sophisticated sampling design and large number of observations. Our estimates were derived from 2713 bariatric surgery patients in 1998; 4595 in 1999; 6563 in 2000; 11 347 in 2001; and 14 926 in 2002. These numbers exceed most currently available clinical series and are weighted to provide national estimates.

Second, we relied on ICD-9 codes to capture bariatric surgery admissions; however, procedural innovation during the study period outpaced ICD-9 coding. Although laparoscopy has been widely performed since the late 1990s, like other investigators,⁴² we were unable to identify laparoscopic procedures with certainty. Similarly, we could not distinguish between vertical banded gastroplasty (introduced in 1980) and adjustable gastric banding (approved in 2001). To identify malabsorptive procedures, we had to combine multiple codes. Future research using administrative data will benefit from the use of more specific procedure codes in the *International Statistical Classification of Diseases, 10th Revision*.

Third, the administrative data we used cannot assess the benchmark 30-day morbidity and mortality used to measure perioperative safety in clinical series. All personal identifying information is eliminated to protect the confidentiality of patients included in the NIS. Therefore, we were unable to link our findings to vital statistics or follow-up hospitalizations. A study by Flum and Dellinger¹⁹ linked administrative data from Washington with vital statistics, and found a 2% rate of 30-day mortality after bariatric surgery. This rate exceeds the mortality in most published clinical series by almost 4-fold and is 5 to 10 times higher than our in-hospital estimates. However, we assessed a thorough list of acute complications occurring over a 5-year period after a variety of bariatric procedures. Carbonell et al⁴² conducted a 1-year, unweighted, cross-sectional

analysis of complications that was limited to gastric bypass admissions. Two previous studies^{16,17} of trends in complications were limited to gastric bypass and vertical banded gastroplasty. Another study that also included malabsorptive procedures grouped together admissions over a 5-year period and did not examine trends.²¹ Our description of the most recent population-based trends of in-hospital complications complements recent meta-analyses^{43,44} describing the long-term efficacy of bariatric surgery, and provides timely and important data for policymakers and insurance providers who are currently debating the safety of bariatric surgery.

Fourth, our study was limited by the variables in the data set. As in other studies using the NIS,^{16,45-47} we could not examine patient race because some states in the NIS systematically do not report race and, among those that do, 20% of observations are missing race data. Given the well-documented racial disparities in the prevalence of obesity,^{1,48-52} data on race of bariatric surgery patients may have had significant implications. Our conclusions about patient socioeconomic status are based on type of insurance and a proxy for household income. The NIS reports income using 4 strata based on the average annual household income in the patient's area of residence, a proxy measure that may result in misclassification. However, we found that private insurance and higher ZIP code level income were highly correlated.

Fifth, the NIS does not include BMI or obesity-related comorbidities (sleep apnea, osteoarthritis, etc), which are not captured well in administrative data. Therefore, although we did find an increase in comorbidities using the Deyo adaptation of the Charlson Index, we did not have enough clinical information to describe trends in surgical indications or obesity-related health conditions. Moreover, most patients in this study had no comorbid conditions (Charlson Index of 0), which may reflect incomplete coding and limits inferences about trends in comorbidity.

These coding limitations are common to administrative data, but the NIS remains the best and most current source for nationwide population-based trends in bariatric surgery.

In light of our finding that in-hospital morbidity and mortality appeared stable or improved despite higher risk patients, recent data on the long-term efficacy of surgery,^{43,44,53} and increasing consensus that surgery is the only effective long-term treatment for morbid obesity,⁵³⁻⁵⁶ our findings that bariatric surgery patients were more likely to be women from higher socioeconomic groups are concerning. State-level data through 2003 suggested that these latter disparities may have worsened. Disproportionate sociocultural pressures to be thin may explain the imbalance between men and women undergoing an elective procedure for weight loss. Type of insurance coverage also may play a role in socioeconomic disparities.

During our entire study period, the Center for Medicare & Medicaid Services covered bariatric surgical procedures for patients with both a BMI higher than 35 and obesity-related comorbidities. The Center for Medicare & Medicaid Services has recently changed its policies to include patients with a BMI higher than 40, but without obesity-related comorbidities.⁵⁶ This decision may increase bariatric surgery use among Medicaid patients. However, many US individuals from low-income groups do not qualify for Medicaid; it is unlikely that the changes in coverage by the Center for Medicare & Medicaid Services alone will improve the socioeconomic disparities we found. Other sources of disparities include the possibility that cultural attitudes toward morbid obesity may differ by socioeconomic status, that primary care physicians may be less likely to refer patients of lower socioeconomic status for bariatric surgery, or that hospitals providing bariatric surgery may be less accessible to lower socioeconomic groups.

The field of bariatric surgery has changed dramatically in the 14 years

since the National Institutes of Health Consensus Conference statement¹¹ and these 1991 guidelines are being reexamined. As bariatric surgeons continue to improve procedures for weight loss, researchers and policymakers should examine factors associated with the uneven use of bariatric surgery. They also should study the impact of the media, cultural beliefs about body weight and health, patient socioeconomic status, and surgeon motivations on the rapid growth of bariatric surgery and differential use rates. Public health campaigns focusing on the health dangers of obesity may help shift thinking about obesity from a cosmetic concern of women to a health concern for both sexes.

With increased knowledge of bariatric surgery indications, risks, and benefits among health care professionals, bariatric surgery is likely to become the standard of care for morbidly obese individuals. Together, these changes should lead to more morbidly obese patients of both sexes and all socioeconomic groups seeking surgery. Although preventing obesity should remain the focus of US health care, efforts must be made to ensure equal access to bariatric surgery irrespective of sex and socioeconomic status for those who are morbidly obese, have an indication for surgical intervention, and wish to undergo an elective surgical procedure to improve health, longevity, and quality of life.

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Study concept and design: Santry, Gillen, Lauderdale.
Acquisition of data: Santry.

Analysis and interpretation of data: Santry, Gillen, Lauderdale.

Drafting of the manuscript: Santry.

Critical revision of the manuscript for important intellectual content: Gillen, Lauderdale.

Statistical analysis: Santry, Gillen.

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Starting a novel is opening a door on a misty landscape; you can still see very little but you can smell the earth and feel the wind blowing.

—Iris Murdoch (1919-1999)