Effective Health Care Program
Research Reports

Number 28

Prompt Reduction in Use of Medications for Comorbid Conditions After Bariatric Surgery

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Research from the Developing Evidence to Inform Decisions about Effectiveness (DEcIDE) Network

AHRQ
Agency for Healthcare Research and Quality
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June 2010

The DEcIDE (Developing Evidence to Inform Decisions about Effectiveness) network is part of AHRQ's Effective Health Care Program. It is a collaborative network of research centers that support the rapid development of new scientific information and analytic tools. The DEcIDE network assists health care providers, patients, and policymakers seeking unbiased information about the outcomes, clinical effectiveness, safety, and appropriateness of health care items and services, particularly prescription medications and medical devices.

This report is based on research conducted by the Johns Hopkins University DEcIDE (Developing Evidence to Inform Decisions about Effectiveness) Center under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD (Contract No. HHSA29020050034-1 TO2). The AHRQ Task Order Officers for this project were Michael Handrigan, M.D., and Scott R. Smith, Ph.D.

Financial Disclosure: The dataset used in this current study was originally created for a different research project on patterns of obesity care within selected Blue Cross/Blue Shield (BCBS) plans. The previous research project (but not the current study) was funded by unrestricted research grants from Ethicon Endo-Surgery, Inc. (a Johnson & Johnson company); Pfizer, Inc.; and GlaxoSmithKline. The data and database development support and guidance were provided by the BCBS Association; BCBS of Tennessee; BCBS of Hawaii; BCBS of Michigan; BCBS of North Carolina; Highmark, Inc. (of Pennsylvania); Independence Blue Cross (of Pennsylvania); Wellmark BCBS of Iowa; and Wellmark BCBS of South Dakota. All investigators had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All listed authors contributed to the design, analysis, or writing of this study. None of the authors has a financial interest in any of the products discussed in this report.

This report has been published in edited form: Segal JB, Clark JM, Shore AD, et al. Prompt reduction in use of medications for comorbid conditions after bariatric surgery. Obes Surg 2009 Dec;19(12):1646-56.

Suggested citation:

Segal JB, Clark JM, Shore AD, Dominici F, Magnuson T, Richards TM, Weiner JP, Bass EB, Wu AW, Makary MA. Prompt reduction in use of medications for comorbid conditions after bariatric surgery. Effective Health Care Research Report No. 28. (Prepared by Johns Hopkins University DEcIDE Center under Contract No. HHSA29020050034-1 TO2.) Rockville, MD: Agency for Healthcare Research and Quality. June 2010. Available at: http://effectivehealthcare.ahrq.gov/reports/final.cfm.

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Abstract

Background. Bariatric surgery leads to weight loss, but it is unclear whether surgery reduces conditions associated with obesity. We explored this by assessing the change in use of medications to treat diabetes mellitus, hypertension, and hyperlipidemia in the year following surgery.

Methods. Cohort study using administrative data from 2002–2005 from 7 Blue Cross/Blue Shield Plans. We compared the mean number of medications at the time of surgery and in the subsequent year. Medication usage by surgical patients was also compared to usage by matched-enrollees without surgery but with a propensity score suggesting obesity. With Poisson and logistic regression, we tested for statistical differences in usage accounting for repeated measures, controlling for age, sex and diabetes. We also evaluated medications expected to be less influenced by surgery (antidepressants, thyroid replacement, and antihistamines).

Results. Our cohort included 6,235 enrollees with bariatric surgery. Their mean age was 44 years with 82% women; 34% had diabetes. Medication use declined significantly by 3 months. By 12 months after surgery, medication use for diabetes, hypertension, and hyperlipidemia had declined 76%, 51%, and 59%, respectively. In contrast, thyroid hormone, antihistamine, and antidepressant use decreased by only 6%, 15% and 9%, respectively. Enrollees without surgery had a modest increase in medications for diabetes, hypertension, and hyperlipidemia of 4%, 8% and 20%, respectively.

Conclusions. Medication use for 3 serious, obesity-associated conditions decreased promptly following surgery. The clinical and economic benefits of reduced medication requirements should be considered when making decisions about the effects of bariatric surgery.

Introduction

Roughly one third of the United States population is obese.[1] The prevalence is rising rapidly both in the United States and world wide.[2] This will increasingly impact the health care system as obesity-related comorbidity is associated with high utilization of resources, including inpatient and outpatient services, and medications.[3-6]

The efficacy of bariatric surgery for weight reduction is well established.[2,7] It is unclear, however, how this translates into a reduction in obesity-related complications and associated health care utilization. While several series[2,7] and one randomized trial[8] have demonstrated that bariatric surgery reduces the use of medications for treating diabetes, it is less clear whether surgery reduces utilization of medications for other chronic conditions that often afflict individuals with obesity and diabetes.[9]

To improve understanding of the effects of bariatric surgery on the highly prevalent, life-threatening comorbid conditions associated with obesity, we studied the use of medications to treat diabetes mellitus, hypertension, and hyperlipidemia and in the year following bariatric surgery. We hypothesized that use of these medications would decrease after surgery. In contrast, we hypothesized that use of medications for depression, hypothyroidism and allergic rhinitis would remain stable.

Methods

This is a historical cohort study using administrative data from January 1, 2002 through December 31, 2005.

Data Acquisition

We accessed claims data from seven Blue Cross Blue Shield health plans providing coverage in Western Pennsylvania, Philadelphia, South Dakota, Iowa, Hawaii, Michigan, North Carolina, and Tennessee. The data were de-identified in accordance with the Health Insurance Portability and Accountability Act's (HIPAA) definition of a limited data set. The data were used in accordance with federal standards for protecting the confidentiality of the personal health information of the enrollee. The Johns Hopkins Institutional Review Board deemed the study to be exempt from Federal regulations because the research activities were considered to be of minimal risk to subjects.

We requested claims on members who met any of these inclusion criteria during 2002 through 2005: (1) completed a health risk assessment with member height and weight; (2) had a claim with a diagnosis of obesity; (3) had a paid or denied claim for bariatric surgery (see Appendix A); (4) had a paid or denied claim for a medication for promoting weight loss; or (5) were greater than 12 years old and had a diagnosis of hyperlipidemia, type 2 diabetes mellitus, sleep apnea, gall bladder disease or surgery, or metabolic syndrome. These diagnoses were identified in the claims by Common Procedural Terminology (CPT) codes, International Classification of Disease-9 Clinical Modification (ICD-9-CM) codes, National Drug Codes (NDC) or Diagnosis Related Group (DRG) codes.

The following data were acquired: (1) enrollment files for administrative data; (2) benefits information to determine medical and pharmacy coverage; and (3) inpatient, outpatient,

and pharmacy claims records containing ICD-9 diagnosis, CPT codes, prescription NDC codes, and costs and charges (submitted, allowed, and paid).

Defining the Cohort

For inclusion in our analytic cohort, we required that the enrollee:

- Have 6 months of continuous coverage, including pharmacy coverage, prior to the index date, defined as the date of bariatric surgery for patients who underwent surgery and, for those who did not have surgery, as the date of plan enrollment plus the mean time from the later of plan enrollment or January 2002 to surgery of the surgical patients (16 months)
- Have 12 months of continuous coverage, including pharmacy coverage, after the index date
- Be between 18 years and 64 years, inclusive
- Not have a diagnosis of cancer of the esophagus (ICD-9 150-150.9), stomach (ICD-9 151-151.9), small intestine (ICD-9 152-152.9) or pancreas (ICD-9 157-157.9), or other digestive malignancy (DRG 172-173)

Creating Variables

Medications were grouped using the Johns Hopkins University ACG Case-Mix System (version 8.0 beta) into therapeutic categories using the NDC codes in the claims.[10] It was assumed that a patient would not be on more than one drug from any therapeutic class.(Appendix B) For select outcomes, we stratified results by diagnosis of diabetes defined as at least one ICD-9 code of 250.xx or a pharmacy claim for any drug for treating diabetes prior to the index date.

We tabulated the number of unique therapeutic classes of drug that the patient had "on hand" at the time points of interest. We knew the date that each prescription was filled and the number of days of drug supplied. If this supply would result in the patient having sufficient drug "on hand" to overlap with a seven day window surrounding the time point of interest, the patient was considered to have been on this medication on that date. Medication that might be considered to be "extra" due to an early refill was added to the end of the next prescription fill for the tabulation of drug "on hand."

We created additional variables for description and to use in modeling outcomes, including demographics (age, sex), utilization variables (hospitalizations, outpatient visits, medical and pharmacy payments) and other indicators of health status including the Resource Utilization Band from the Johns Hopkins University ACG Case-Mix System.[10]

Statistical Methods

We explored medication use in two ways: (1) a pre/post analysis of medication usage for surgical patients only; and (2) a pre/post analysis of medication usage for surgical patients compared to a group of enrollees *predicted* to be obese who did not undergo bariatric surgery. We also examined use of medications for depression, hypothyroidism, and allergies; conditions which we hypothesized would not change after surgery. We tabulated the mean number of medications at each time period for the figures.

Pre-post analysis. The primary comparisons were medication usage at 3, 6, and 12 months after surgery in comparison to usage at surgery. Medication usage was explored as the proportion of

patients who were using at least one medication within a category at these times, and as the mean number of medications used per person within a category. For medication categories with only one drug (e.g., levothyroxine), these are equivalent.

For estimating the percent change in use of diabetes and antihypertensive medications post- versus pre-surgery, we used Poisson regression and general estimating equations (GEE), since we had counts ranging from 0 to 4 medications per person and repeat measures for the same enrollee.[11] For the other medication classes, we used logistic regression with GEE as patients were generally on either one or no medications. A diagnosis of diabetes was included in the models as a covariate to test for differences by diabetes diagnosis where the analyses were not stratified by diabetes. Age and sex and their interactions with time were included in the models as categorical variables although they were not predictive of outcomes.

Comparison group without surgery. We identified enrollees who were predicted to be obese, but who had not undergone bariatric surgery. A model for the propensity to have a body mass index greater than 35 kg/m^2 was previously developed using this administrative database and the body mass index as reported by a subset of the enrollees in their Health Risk Assessment. (Appendix C) We reviewed the distribution of the propensity scores and identified all non-surgical enrollees who had propensity scores above the 90th percentile (16% of all enrollees), while excluding women who were pregnant within one year of the index date. In the validation subset, a score above the 90th percentile had a positive predictive value for obesity of 78%. We individually matched enrollees in this upper decile from the non-surgical group to enrollees in the surgical group by exact age, sex and presence or absence of diabetes at a ratio of 3:1, if sufficient matches were available.

We tabulated medication usage for the non-surgical patients at 3-month intervals beginning at 6 months prior to their index date until one year after their index date. We estimated the change in medication use post- versus pre-surgery for the surgical patients and compared this to the change for the non-surgical group. As described above, we used Poisson and logistic regressions with GEE, while adjusting for age and sex, their interactions with time, and diagnosis of diabetes. The analyses for each class of medication were stratified by diagnosis of diabetes when the diagnosis of diabetes was significantly associated with the change in medication use over time. Analyses were done using SAS version 9.13 (SAS Institute, Cary, NC).

Results

Our cohort included 6,235 bariatric surgery patients, with 34% coded to have diabetes mellitus. Table 1 shows the characteristics of the surgical group and the comparison group of enrollees predicted to be obese. The median age of the surgical patients was 44 years, and the majority was female. Hypertension was the most prevalent comorbidity, affecting 53% of the surgical patients. The matching procedure, using the obesity propensity score, was successful as the characteristics of the patients in the two groups, before the index date, were largely similar. Many of the differences were statistically significant in this large cohort, although the clinical relevance was thought to be modest. On the whole, the surgical group had more comorbid illness than the comparison group, while the non-surgical group was older.

Change in Medication Use in the Surgical Cohort

There was a prompt decrease in the mean number of medications used in the post-surgery period for the medication classes that we hypothesized would be affected by bariatric surgery or by weight loss (Table 2). By 3 months after surgery, the mean number of medications on hand for diabetes, among enrollees with diabetes, decreased by 55%. Anti-hypertensive medication use decreased by 34% among enrollees with diabetes and by 59% among those without diabetes. Lipid-lowering therapies decreased by 55% and 52% among enrollees with and without diabetes, respectively. There was a more modest decrease in the mean number of prescriptions filled for antidepressant medications, with a 9% decrease by 12 months. Over the same time period, antihistamine use decreased by 15%. Use of thyroid replacement medication remained relatively constant.

In the analyses stratified by diagnosis of diabetes, for the classes of antihypertensive and lipid-lowering medications (Table 2), we found that patients with diabetes were on more medications at baseline than patients without diabetes. The patients with diabetes had a smaller percentage decrease in the number of antihypertensive medication at each time point after surgery than patients without diabetes, but a comparable decrease in the use of lipid-lowering medications.

Change in Medication Use Relative to Comparison Population

As shown in Table 3, medication usage prior to the index date was very similar in the surgical patients and the non-surgical comparison group. Medication usage in the year after the index date, however, differed markedly between the surgical and non-surgical groups (Figure 1 and Table 3). While there was a prompt *decrease* of 74% by 12 months in the mean number of diabetes medications filled by surgical patients, in the comparison groups, the number of medications filled *increased* by 4%. Similarly, the mean prescription fills for antihypertensive medications and lipid-lowering medications decreased markedly in the surgical group, and increased in the non-surgical group, both for patients with and without diabetes. The differences between groups were much less pronounced for antidepressant, thyroid hormone, and antihistamine medications.

Comment

The use of medications for diabetes, hypertension, and hyperlipidemia; conditions that should be responsive to weight loss or to the metabolic consequences of the surgery, decreased markedly soon after surgery. There were smaller decreases in the use of medications that we did not expect to be responsive to the surgery. Patients without diabetes had a greater reduction in their use of antihypertensive medications than patients with diabetes, which could be due to physicians' more aggressive treatment of hypertension in patients with diabetes for nephroprotection or for prevention of cardiovascular complications.[12]

Our use of a comparison group strengthens the evidence that the changes observed were causally related to the surgery rather than to secular changes, or due to how pharmacy claims were recorded or our method for counting medications. When we compared the patients who had surgery to a matched group of enrollees who were predicted by our model to be obese but did not have bariatric surgery, we found that their baseline medication use was similar. There was a striking divergence in the curves for medication use after the index date. The surgical group had

somewhat more comorbidity than the comparison group, but this should have been a conservative bias.

These changes in medication use happened quickly after surgery. The curves diverged by 3 months after surgery. The metabolic changes that occur early after bariatric surgery may be playing an important role in reducing needs for medication. Resolution of diabetes is likely not due to weight loss alone, but may be mediated by gastric hormones;[13] the three most implicated being peptide YY (PPY) glucagon-like-peptide (GLP-1), and pancreatic polypeptide (PP). GLP-1, a known mediator of insulin regulation, increases immediately following bariatric surgery, which may explain the very rapid resolution of diabetes.[14] The newer medications for diabetes targeting these pathways, exenatide and pramlintide, were not yet available during the years covered by this data. The resolution of diabetes may also be a consequence of the forced, substantial reduction in caloric intake due to the restrictions of the surgical procedures. Less clear is the mechanism for the rapid resolution of hyperlipidemia and hypertension, although this has been described previously.[15,16]

There is a small body of literature about depression and other Axis I psychiatric diagnoses in patients who undergo bariatric surgery, with estimates that roughly one quarter of surgical patients have affective disorders, and an additional 10% have eating disorders.[17,18] There are few studies in the literature about changes in psychiatric diagnoses after bariatric surgery, with some demonstrating improvement in depressive symptoms and others documenting development of new depressive symptoms and an increased incidence of suicide postoperatively.[19-22] We could not assess with this data whether the dosages of antidepressant medication changed with weight loss.

We cannot conclude definitively that bariatric surgery eliminates diabetes, hypertension, and hyperlipidemia. Indeed, we hope that the decreased use of these medications is due to resolution of these conditions, rather than physician and patient nonadherence to treatment recommendations. A recent study of bariatric surgery that used Medicare data found reductions in comorbid conditions after surgery comparable to what we observed.[23] That study relied exclusively on ICD-9-CM codes to identify comorbid conditions. Our observations complement this study and advance their observations in that we examined other comorbid conditions thought not to change with surgery and in this way demonstrated the sensitivity of our methodology to the surgical intervention. Also, with the use of pharmacy claims, we were less likely to miss comorbid conditions that were under coded at the time of visits.

Limitations

With administrative data, we could only know diagnoses based on diagnostic or procedural codes. There may have been more complete coding of diagnoses among the enrollees in the surgical group, as the presence of comorbid illness is needed to assure coverage of the procedure among those with lower body mass indexes. Indeed, virtually all patients undergoing surgery had a diagnosis code for obesity while few of the non-surgical patients did. We expect, however, that the comparison group was indeed obese; obesity is consistently under-coded as a diagnosis.[24,25] Administrative data are not adequate for describing the severity of individual conditions among enrollees; however, we used the well-validated ACG Case-Mix system for predicting the global burden of illness for an individual.

Our estimates of medication use were based on pharmacy claims. This only indicates that the prescription was filled; we cannot judge daily adherence to the medication. Additionally, we cannot definitively know the diagnosis for which the patient was taking a medication,

particularly for those drugs with multiple indications (e.g., bupropion). For this analysis, however, filling the medication should be an adequate proxy for use of the medication because our primary interest is not a physiological measure, but is the *change* in medication use over time. These enrollees were all privately-insured patients and we cannot conclude that the same changes in medication utilization would be observed in patients with coverage from Medicaid or Medicare.

Future research should investigate whether these observed changes in medication use are sustained past 12 months. With clinical data, it should be verified that the change in medication fills actually signifies a decrease in the prevalence of these diseases. Additional research on the impact of bariatric surgery on other illnesses is needed, including on outcomes from other surgical procedures done after the bariatric procedure.

Conclusion

We conclude that bariatric surgery is effective for decreasing the use of medications for obesity-related diabetes, hypertension, and hyperlipidemia. This information can inform decisions about bariatric surgery and should be included in discussions with patients making decisions about bariatric surgery. Our results should be motivating to physicians caring for patients with these lethal, obesity-associated illnesses. It is conceivable that intervention with surgery may decrease the cardiovascular complications of diabetes, hypertension, and hyperlipidemia. Additionally, the possibility of eliminating medications and the resulting cost reductions and reduction in risks associated with medications may be highly valued by patients. We do not discount that there may be increases in use of other classes of medications.

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Tables and Figure

Table 1. Characteristics of the bariatric surgery group and the matched comparison group of non-surgical patients likely to be obese

	Surgical Group (N=6,235)	Non-Surgical Comparison Group (N=16,116)
Age in years, %		
18-34	20	6.8
35-44	30	35
45-54	34	40
55-65	16	19
Mean years (SE)	44 (0.12)	46 (0.07)
Male, %	18	21
Year of Enrollment, %		
2002	84	84
2003	13	16
2004	3.8	0
Type of Surgery, %		
Gastric Bypass	80	NA
Gastric Banding	1.6	NA
Other	18	NA
Comorbid Conditions, %		
Hypertension	53	47
Diabetes	34	39
Hyperlipidemia	23	19
IHD	7.8	5.2
CHF	2.2	2.4
Depression	19	7.8
Sleep Apnea	30	11
GERD	36	8.5
Obesity	97	5.2
Resource Utilization Band*, (% in each percentile category)		
1 -20	0.7	8.2
21-40	3.2	17
41-60	67	60
61-80	22	11
81-100	7.3	4.2
Total medical costs in 6 months preceding surgery, $ (mean SE)	4,046 (57)	2,421 (40)
[median]	[2,061]	[876]
Total pharmacy costs in 6 months preceding surgery, $ (mean SE)	1,231 (20)	1,199 (13)
[median]	[734]	[754]

CHF=congestive heart failure; GERD=gastroesophageal reflux disease; IHD=ischemic heart disease, NA=not applicable; *from the ACG-case Mix System—an indicator of resource utilization

Table 2. Medication use per person following bariatric surgery*

Medication Class		Average Medication Count at Surgery [95% Confidence Interval]	Count at 3 months (and % decrease)	Count at 6 months (and % decrease)	Count at 12 months(and % decrease)
Diabetes	Diabetic Patients Only:	1.1 [0.96-1.2]	0.45 (58)	0.35 (68)	0.27 (75)
Anti-hypertensives	Diabetic Patients:	1.0 [0.91-1.1]	0.66 (34)	0.61 (39)	0.55 (45)
	Non-diabetic Patients:	0.72 [0.67-0.78]	0.41 (43)	0.37 (48)	0.33 (54)
Medication Class		**Probability of Medication at Surgery [95% Confidence Interval]**	**Probability of Medication at 3 Months (and % decrease)**	**Probability of Medication at 6 Months (and % decrease)**	**Probability of Medication at 12 Months (and % decrease)**
Lipid-lowering	Diabetic Patients:	0.34 [0.33-0.37]	0.15 (55)	0.16 (52)	0.15 (55)
	Non-diabetic Patients:	0.16 [0.14-0.18]	0.076 (52)	0.065 (59)	0.065 (59)
Anti-depressants	All Patients†	0.39 [0.37-0.41]	0.33 ‡ (15)	0.34 ‡ (12)	0.36 § (9)
Thyroid Replacement	All Patients†	0.17 [0.15-0.19]	0.16 (4.1)	0.16 (4.6)	0.16 (6.6)
Antihistamines	All Patients†	0.10 [0.083-0.11]	0.074 (23)	0.078 (19)	0.082 (15)

*predicted results for females aged 45 to 54 years; all p-values for change over time ≤ 0.0001 unless specified
†controlled for presence of diabetes, ‡ $p \leq 0.05$, §$p \leq 0.001$

Table 3. Medication use in the bariatric surgery group and the matched non-surgical group of patients likely to be obese*

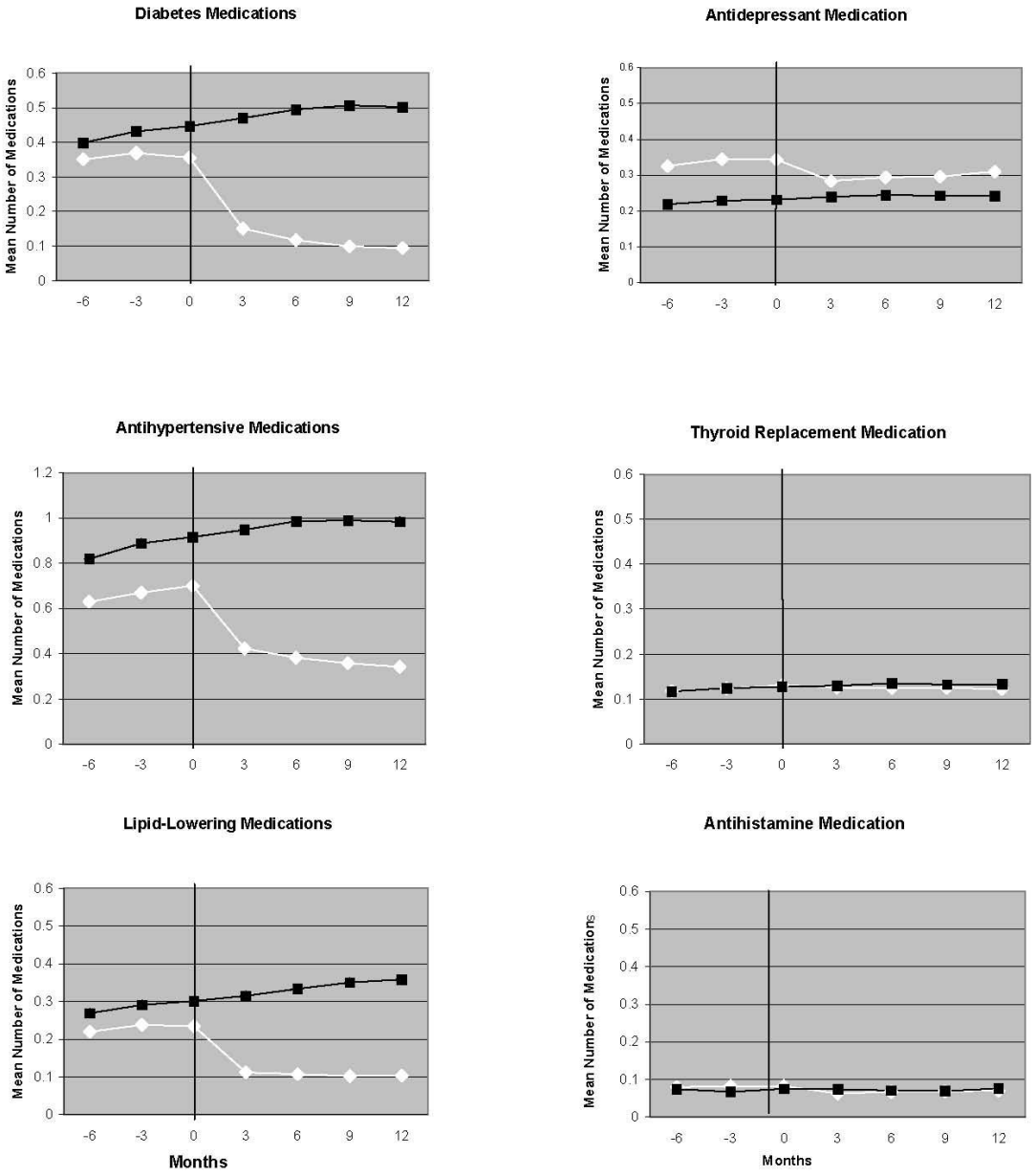
Medication Class		Average Count of Medications at Index Date [95% Confidence Interval]		Average Count of Medications at 12 months [95% Confidence Interval] (and % change from index date)	
		Surgical Group	**Non-surgical Group**	**Surgical Group**	**Non-surgical Group**
Diabetes	Diabetic Patients	1.07 [1.02-1.12]	1.15 [1.12-1.19]	0.28 [0.25-0.31] (74% decrease)	1.20 [1.16-1.24] (4% increase)
Antihypertensives	Diabetic Patients	1.03 [0.98-1.09]	1.06 [1.02-1.10]	0.55 [0.51-0.60] (46% decrease)	1.10 [1.06-1.14] (4% increase)
	Non-diabetic Patients	0.69 [0.66-0.73]	0.93 [0.90-0.96]	0.31 [0.28-033] (55% decrease)	1.02 [0.98-1.05] (9% increase)
Medication Class		**Probability of Patient Using Medication at Index Date [95% Confidence Interval]**		**Probability of Patient Using Medication after 12 months [95% Confidence Interval] (and change from index date)**	
		Surgical Group	**Non-surgical Group**	**Surgical Group**	**Non-surgical Group**
Lipid-lowering	Diabetic Patients	0.34 [0.32-0.37]	0.35 [0.33-0.37]	0.16 [0.14-0.17] (54% decrease)	0.39 [0.37-0.40]** (10% increase)
	Non-diabetic Patients	0.15 [0.14-0.17]	0.20 [0.19-0.22]	0.064 [0.06-0.07] (59% decrease)	0.25 [0.24-0.26]** (23% increase)
		Probability of Patient Using Medication at Index Date [95% Confidence Interval]		**Probability of Patient Using Medication after 12 months [95% Confidence Interval] (and change from index date)**	
Antidepressants	All Patients†	0.39 [0.36-0.40]	0.26 [0.24-0.26]	0.36 [0.33-0.36] (9% decrease)	0.27 [0.25-0.27]‡ (3% increase)
Thyroid Replacement	All Patients†	0.18 [0.16-0.18]	0.16 [0.15-0.18]	0.16 [0.15-0.18] (6% decrease)	0.17 [0.16-0.19]‡ (4% increase)
Antihistamines	All Patients†	0.098 [0.07-0.09]	0.086 [0.08-0.09]	0.083 [0.08-0.09] (15% decrease)	0.086 [0.08-0.09]‡ (1% increase)

*adjusted for age and sex and their interaction with time with results predicted for females aged 45 to 54 years

† controlled for presence of diabetes

‡ $p<0.0001$ for difference in change between the two groups

Figure 1. Mean medication use over time in surgical patients and in a non-surgical comparison group



White Diamonds=Surgical Group
Black Squares=Non-surgical Group of Individuals Predicted to be Obese

Appendixes

Appendix A. Bariatric Operations

DRG codes	288	Procedures for Obesity	Other
CPT codes	43644	Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and Roux-en-Y gastroenterostomy (roux limb 150 cm or less)	Gastric bypass
	43645	Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and small intestine reconstruction to limit absorption	Gastric bypass
	43659[2]	Unlisted laparoscopy procedure, stomach	Other
	43810[1]	Gastroduodenostomy	Other
	43820[1]	Gastrojejunostomy without vagotomy	Other
	43825[1]	Gastrojejunostomy with vagotomy any type	Other
	43842	Gastric restrictive procedure, without gastric bypass, for morbid obesity; vertical-banded gastroplasty	Banding
	43843	Gastric restrictive procedure, without gastric bypass, for morbid obesity; other than vertical-banded gastroplasty	Other
	43845	Gastric restrictive procedure with partial gastrectomy, pylorus-preserving duodenoileostomy and ileoileostomy (50 to 100 cm common channel) to limit absorption (biliopancreatic diversion with duodenal switch)	Other
	43846	Gastric restrictive procedure, with gastric bypass for morbid obesity; with short limb (150 cm or less) Roux-en-Y gastroenterostomy	Gastric bypass
	43847	Gastric restrictive procedure, with gastric bypass for morbid obesity; with small bowel reconstruction to limit absorption	Gastric bypass
	43999[2]	Unlisted procedure, stomach	Other
	44238[2]	Unlisted laparoscopy procedure,intestine (except rectum)	Other
HCPCS codes	S2082	Laparoscopy, surgical; gastric restrictive procedure, adjustable gastric band includes placement of subcutaneous port	Banding
	S2085	Laparoscopy, gastric restrictive procedure, with gastric bypass for morbid obesity, with short limb (less than 100 cm) Roux-en-Y gastroenterostomy (code no longer in use after 12-31-04)	Gastric bypass
ICD-9-CM procedure codes	435[1]	Partial gastrectomy	Other
	436[1]	Distal gastrectomy	Other
	437[1]	Partial gastrectomy with jejunal anastomisis	Other
	4389[1]	Sleeve gastrectomy	Other
	4431	High gastric bypass	Gastric bypass
	4438[2]	Laparascopic gastroenterostomy	Other
	4439[2]	Gastroenterostomy NEC	Other
	4468[2]	Laparoscopic gastroplasty	Other
	4493[2]	Gastric bubble insertion	Other
	4495	Laparoscopic gastric restrictive procedure	Other
	4499[2]	Gastric operation not elsewhere classified	Other
	4550[1]	Isolated intestinal bypass, small bowel to small bowel anastomosis	Other
	4551[1]	Isolated intestinal bypass, small bowel to segment isolation	Other
	4590[1]	Isolated intestinal bypass, intestine to intestine anastomosis not otherwise specified	Other
	4591[1]	Isolated intestinal bypass, intestinal isolation not otherwise specified	Other

[1]Must be accompanied by DRG 288
[2]Must be accompanied by DRG 288 or another bariatric surgery procedure

DRG =Diagnosis-Related Groups; CPT = Current Procedural Terminology;
HCPCS =Health Care Common Procedure Coding System, Level II;
ICD-9-CM = International Classification of Diseases revision 9, Clinical Modification

Appendix B. Medications of Interest

Medication Category	Therapeutic Classes
Antihypertensive Medications	angiotensin converting enzyme inhibitor calcium-channel blocker angiotensin receptor blocker diuretic beta-blocker other antihypertensive medications
Lipid-lowering Medications	HMG-CoA reductase inhibitor fibrates niacin bile acid sequestrant other lipid lowering therapies
Diabetes Treatments	insulin pramlintide sulfonylureas biguanides thiazolidinedione alpha glucosidase inhibitors meglitinides glucagon-like peptide agonist
Antidepressants	tricyclic antidepressants selective serotonin reuptake inhibitors other antidepressants
Thyroid Replacement	not further classified
Antihistamines*	not further classified

*in 11/2002, loratadine became available over the counter

Appendix C. Description of the Development and Validation of a Propensity Score for Obesity

Introduction

Obesity is associated with many comorbidities and disability. Obesity is typically under-coded by practicing physicians, hampering efforts for disease management or research on obesity using administrative data.[C1-C4] Our objective was to develop a propensity score model based on clinical data found in health plans claims files. The ultimate goal was to identify patients with Class II or III obesity (BMI $\geq$ 35 kg/m^2). For this project this tool was used to identify a non-surgical cohort to serve as a comparison group for a cohort of patients undergoing bariatric surgery.

Methods

We used data from "health risk appraisal" (HRA) surveys from 3 participating BCBS plans, which included self-reported height and weight, and linked it to claims data from 2002-2005 (N=115,495). We then excluded records with any of the following:

- < 6 months coverage in the year in which the HRA was completed (N=16,810)
- Missing data regarding age or age <18 years (N=135)
- Had a bariatric surgery claim during the study period (N=171)
- Had a pregnancy claim during the study period (N=3,493)
- BMI unable to be calculated or BMI <10 kg/m^2 or >100 kg/m^2 (N=625)

Our final sample (N=71,057) was randomly split in two subsamples, one for development (N=35,529), and one for validation (N=35,528).

Our dependent outcome was class II or III obesity, defined by a BMI $\geq$35 (from self-reported height and weight). In addition to age and gender, we used ICD-9-CM diagnosis codes that we categorized using the Expanded Diagnosis Clusters (EDC) clustering system as our predictors. We also used prescription drug claims information (NDC codes) to identify additional persons under treatment for disease who may not have been identified using ICD diagnosis codes). This system for categorizing NDC codes based on the likely condition being treated is known as the Rx Morbidity Group (RxMG) system. Both of these disease markers methodologies are part of the widely used and validated Johns Hopkins ACG case-mix / predictive risk methodology (See www.acg.jhsph.edu).[C5,C6]

We conducted bivariate logistic regression analyses to determine which covariates were associated with obesity. We then conducted multivariate logistic regression analyses in several phases using: (1) all variables, (2) stepwise regression to select variables with $p<0.10$, (3) variables with odds ratios >2.0 or < 0.5, and (4) variables anticipated to be associated (+ or -) based on clinical expertise. We reviewed and compared all models and selected a final model. We then tested the model in the second half of the sample. We examined the model by applying it to a large sample of enrollees in 5 participating BCBS plans using data from same time period.

Results

The comparison of the performance of different predictive (propensity) models is shown in Table C-1. We present the "C" statistic (based on "receiver operating characteristics" – ROC, also known as area under the curve).

In our model, the ICD-9-based "obesity EDC" had a very significant and sizable predictive coefficient. (That is, this code significantly contributed information to the prediction that a person's BMI was greater than 35kg/m^2). For case finding purposes, in general populations, this model would be quite useful. Every person receiving bariatric surgery had this EDC code because all persons receiving a bariatric procedure required a hospital diagnosis of obesity for payment of the claim. However, we found that only about 15% of those persons with a known BMI greater than 35 kg/m^2 (but without bariatric surgery) were coded as having an obesity diagnosis by their providers. Thus the use of this diagnosis code differed among obese persons in our two study cohorts (i.e., those obese persons undergoing surgery versus those not receiving surgery). Therefore, we opted to exclude this single EDC from the final obesity propensity model.

As noted on Table C-1, the final "parsimonious" model included a selection of EDC and RxMG categories while excluding the obesity EDC code. The final model had an ROC of 0.714 in the validation sample.

Table C-2 presents the sensitivity, specificity and positive predictive value (PPV) for different levels of the propensity score for the final model, within the validation half of the HRA survey population. For those persons whose claims-based propensity score fell into the highest 5% percentile, fully 96% reported BMIs greater than 35kg/m^2. This very high specificity suggests that the propensity score can effectively be applied to claims data files to identity a cohort that is extremely likely to be obese.

Table C-1. Comparison of the performance of different models in the validation sample (N=35,528)

Risk Model Based on Claims Data	C-Statistic
Full EDC Model (All 200+ diagnostic categories)	0.718
Parsimonious EDC model (w/o obesity diagnosis)	0.702
Full RxMG Only (NDC codes only; 50+ Rx defined disease/ condition categories)	0.674
Full EDCs + RxMGs (ICD + NDC)	0.731
Final Parsimonious Model with EDC's and RxMG's* (w/o Obesity Indicator; 63 EDCs & 19 RxMGs)	**0.714**

*Model chosen to define comparison group

Table C-2. Screening characteristics of the selected propensity model in the validation sample

Percentile of Propensity Score	Sensitivity	Specificity	PPV
Top 1%	0.06	0.99	0.92
Top 5%	0.19	0.96	0.83
Top 10%	0.29	0.92	0.78
Top 25%	0.52	0.77	0.69

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