

# Health Care Use During 20 Years Following Bariatric Surgery

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**O**VER THE LAST 3 DECADES, the prevalence of obesity greatly increased. The most significant increases have occurred among patients with a body mass index [BMI] of 35 or higher (BMI is calculated as weight in kilograms divided by height in meters squared).<sup>1,2</sup> Such individuals, who are eligible for bariatric surgery, represent 15% of the adult population,<sup>3</sup> incur a disproportionate share of health care costs relative to moderately obese individuals (BMI, 30-34.9),<sup>4</sup> and have greater risk of premature death.<sup>5</sup>

Bariatric surgery reduces weight and improves diabetes, hyperlipidemia, hypertension, and obstructive sleep apnea.<sup>6</sup> Long-term outcomes for surgically induced weight loss from the Swedish Obese Subjects study have demonstrated sustained weight loss, reduced incidence of diabetes, cardiovascular events, and cancer, as well as improved 10- to 15-year survival.<sup>7-12</sup> Although there are many benefits from bariatric surgery, it is not known whether these translate to reduced long-term health care use.

The Swedish study is a long-term prospective, matched cohort study that tracks the effects of bariatric surgery and

**For editorial comment see p 1160.**

**Context** Bariatric surgery results in sustained weight loss; reduced incidence of diabetes, cardiovascular events, and cancer; and improved survival. The long-term effect on health care use is unknown.

**Objective** To assess health care use over 20 years by obese patients treated conventionally or with bariatric surgery.

**Design, Setting, and Participants** The Swedish Obese Subjects study is an ongoing, prospective, nonrandomized, controlled intervention study conducted in the Swedish health care system that included 2010 adults who underwent bariatric surgery and 2037 contemporaneously matched controls recruited between 1987 and 2001. Inclusion criteria were age 37 years to 60 years and body mass index of 34 or higher in men and 38 or higher in women. Exclusion criteria were identical in both groups.

**Interventions** Of the surgery patients, 13% underwent gastric bypass, 19% gastric banding, and 68% vertical-banded gastroplasty. Controls received conventional obesity treatment.

**Main Outcome Measures** Annual hospital days (follow-up years 1 to 20; data capture 1987-2009; median follow-up 15 years) and nonprimary care outpatient visits (years 2-20; data capture 2001-2009; median follow-up 9 years) were retrieved from the National Patient Register, and drug costs from the Prescribed Drug Register (years 7-20; data capture 2005-2011; median follow-up 6 years). Registry linkage was complete for more than 99% of patients (4044 of 4047). Mean differences were adjusted for baseline age, sex, smoking, diabetes status, body mass index, inclusion period, and (for the inpatient care analysis) hospital days the year before the index date.

**Results** In the 20 years following their bariatric procedure, surgery patients used a total of 54 mean cumulative hospital days compared with 40 used by those in the control group (adjusted difference, 15; 95% CI, 2-27;  $P=.03$ ). During the years 2 through 6, surgery patients had an accumulated annual mean of 1.7 hospital days vs 1.2 days among control patients (adjusted difference, 0.5; 95% CI, 0.2 to 0.7;  $P<.001$ ). From year 7 to 20, both groups had a mean annual 1.8 hospital days (adjusted difference, 0.0; 95% CI, -0.3 to 0.3;  $P=.95$ ). Surgery patients had a mean annual 1.3 nonprimary care outpatient visits during the years 2 through 6 vs 1.1 among the controls (adjusted difference, 0.3; 95% CI, 0.1 to 0.4;  $P=.003$ ), but from year 7, the 2 groups did not differ (1.8 vs 1.9 mean annual visits; adjusted difference, -0.2; 95% CI, -0.4 to 0.1;  $P=.12$ ). From year 7 to 20, the surgery group incurred a mean annual drug cost of US \$930; the control patients, \$1123 (adjusted difference, -\$228; 95% CI, -\$335 to -\$121;  $P<.001$ ).

**Conclusions** Compared with controls, surgically treated patients used more inpatient and nonprimary outpatient care during the first 6-year period after undergoing bariatric surgery but not thereafter. Drug costs from years 7 through 20 were lower for surgery patients than for control patients.

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has had a high degree of follow-up. Consequently, this study can analyze health care use patterns among patients after undergoing surgery. The aim of this current study was to assess over 20 years the amount of health care obese patients have used after undergoing bariatric surgery compared with those who were conventionally treated. Hospital days, nonprimary care outpatient visits, and drug costs were investigated using nationwide registries.

## METHODS

The prospective, nonrandomized, controlled Swedish Obese Subjects intervention study recruited patients from September 1, 1987, to January 31, 2001.<sup>7,8</sup> After recruitment campaigns in the mass media and at 480 primary health care centers, an eligibility examination was completed by 6905 individuals, 5335 of whom were eligible and were offered surgery. The 2010 who elected surgical treatment constituted the surgery group. From individuals not electing surgery, a contemporaneously matched control group of 2037 individuals was created using 18 matching variables<sup>8</sup>: sex, age, weight, height, waist-hip circumferences, systolic blood pressure, serum cholesterol and triglyceride levels, smoking status, diabetes, menopausal status, 4 psychosocial variables with documented associations with the risk of death, and 2 personality traits related to treatment preferences. Although a surgery patient and his/her conventionally treated control started the study in the same calendar period, matching was not performed at an individual level. Instead the matching algorithm selected controls so that the current mean values of the matching variables in the control group became as similar as possible to the current mean values in the surgery group according to the method of sequential treatment assignment.<sup>13</sup>

Seven regional ethical review boards approved the study protocol. Informed consent was obtained from all patients.

## Inclusion and Exclusion Criteria

Study groups had identical inclusion and exclusion criteria. The inclusion criteria were age 37 to 60 years and BMI of 34 or more in men and 38 or more in women. These BMI cut points corresponded to an approximate doubling of the mortality rate in both sexes.<sup>14</sup> The exclusion criteria were earlier surgery for gastric or duodenal ulcer, earlier bariatric surgery, gastric ulcer during the past 6 months, ongoing malignancy, active malignancy during the past 5 years, myocardial infarction during the past 6 months, bulimic eating pattern, drug or alcohol abuse, psychiatric or cooperative problems contraindicating bariatric surgery, or other contraindicating conditions (such as chronic glucocorticoid or anti-inflammatory treatment). Patients with hypertension, diabetes, or lipid disturbances were allowed to participate, as were patients who had had a myocardial infarction or a stroke more than 6 months before inclusion.

## Examinations

The index date was the day of surgery for patients in the surgery group and for their matched controls. Baseline examinations in both groups took place approximately 4 weeks before the index date. At baseline and follow-up visits (0.5, 1, 2, 3, 4, 6, 8, 10, 15, and 20 years after the index date), measurements of weight, height, waist circumference, blood pressure, and biochemical variables (not all visits) were obtained.<sup>8</sup> Blood samples were obtained after a 10 to 12 hour overnight fast and analyzed at the Central Laboratory of Sahlgrenska University Hospital (accredited according to European Norm 45001).

## Interventions

The choice of surgery type was made by the operating surgeon, and 265 participants (13%) underwent gastric bypass; 376 (19%), gastric banding; and 1369 (68%), vertical-banded gastroplasty.<sup>15</sup> Eighty-nine percent of the patients underwent open surgery. Control patients received the cus-

tomary nonsurgical obesity treatment at their registration center. No attempt was made to standardize their treatment, which ranged from sophisticated lifestyle intervention and behavior modification to no treatment.

## Outcomes

The primary outcome of the Swedish Obese Subjects study (total mortality) was published in 2007.<sup>9</sup> The main outcome in our current analysis was health care use, measured by hospital days, nonprimary care outpatient physician visits, and drug costs. Outcome data were retrieved from nationwide registries managed by the Swedish National Board of Health and Welfare. Inpatient and nonprimary care outpatient visit data were retrieved from the National Patient Register, and drug dispensation data from the Prescribed Drug Register. The data were linked to the study database via the unique personal identification number assigned to each Swedish resident.

Reporting to the National Patient Register is mandatory for all public hospitals in Sweden. The inpatient registry component commenced in 1964 and attained national coverage in 1987 (the start-year of this study). The nonprimary outpatient care component commenced on a national level in 2001.

The Prescribed Drug Register contains all dispensed prescription drugs from pharmacies in Sweden since July 2005. Because patients were recruited into the Swedish Obese Subjects study between 1987 and 2001, we did not have drug dispensation data for the early follow-up years and show available data from year 7 after the index date.

## Follow-up

Patients were followed up from the index date or date of first data capture in the respective outcome registries (nonprimary outpatient care and drug costs), until 20 years after the index date, death, emigration or date of last

data capture from the registries, whichever came first. End of data capture from the National Patient Register was December 31, 2009, and from the Prescribed Drug Register was May 31, 2011. Because recruitment into the study occurred between 1987 and 2001, while registry data were only available on nonprimary care outpatient visits for 2001-2009 and drug costs for 2005-2011, patients contributed outcome data and person-time in different follow-up years, depending on year of study entry.

During follow-up, 2 surgery group patients requested to be deleted from the research database, and a third later obtained an unlisted personal identification number making linkage from that time point impossible. Follow-up regarding inpatient and nonprimary care outpatient visits and prescription drug dispensations was hence complete for 99.9% (4044 of 4047).

### Statistical Analysis

Analyses were performed by intention to treat, including all patients according to their initial treatment group allocation. Mean values and standard deviations or 95% confidence intervals were used to describe the baseline characteristics and changes over time in the study groups. Statistical analyses were performed using SAS version 9.2 (SAS Institute Inc). Reported *P* values are 2-sided, and *P* values <.05 were considered statistically significant.

### Primary Analysis

Mean annual hospital days (follow-up years -4 to 20, data capture 1983-2009), nonprimary care outpatient visits (2 to 20 years, 2001-2009), and drug costs (7 to 20 years, 2005-2011) were calculated for up to 20 years after the index date (1987-2001). All outcomes were skewed, with a longer right tail. Although use of mean values as measure of central tendency for skewed data are generally not considered appropriate, the arithmetic mean has been described as the most informative measure for cost and health care resource

use data.<sup>16,17</sup> Statistical testing was performed on untransformed values with parametric methods and was checked using nonparametric bootstrapping.<sup>16,17</sup> The percentage with inpatient or nonprimary care outpatient visits per year and median drug costs were also calculated.

Mean differences were estimated using linear regression, adjusting for baseline age, sex, BMI, diabetes status, smoking (current smoker yes/no), inclusion period (before or after 1995), and (for inpatient care analysis) hospital days the year before the index date. These adjustments were also used in logistic regressions estimating odds ratios for having an inpatient or nonprimary care outpatient visit.

Mean annual differences were also estimated for the following periods: index year (hospital days), years 2 through 6 (hospital days, nonprimary care outpatient visits), and years 7 through 20 (all 3 outcomes). These estimates were adjusted for the same covariates as mentioned above and weighted by the number of person-years under observation. The period cut points were made post hoc based on observation of the data, previous publications,<sup>13,14</sup> and the availability of data for the cost of drugs.

### Cause of Nonprimary Care Outpatient Visits

Based on main diagnosis classified according to the *International Classification of Diseases (ICD)*, the nonprimary care outpatient visits were also analyzed for visits with diabetes (*ICD-10* codes, E10-E14; *ICD-9* code, 250), cardiovascular disease (*ICD-10*, chapter I; *ICD-9* codes, 390-459), or tumors as the main diagnosis (*ICD-10* codes, C00-D48; *ICD-9* codes, 140-239). This was not done for hospital days because inpatient care admissions were more rare than nonprimary care outpatient visits.

### Drug Costs

Drug costs were inflation adjusted to 2011 Swedish crowns using the Swedish drug price index,<sup>18,19</sup> and

converted to US dollars (exchange rate, 7:1). Based on the *Anatomical Therapeutic Chemical (ATC)* drug classification system, the drug cost was calculated by drugs for diabetes (*ATC* code, A10), gastrointestinal disorders (*ATC* codes, A02-A07), anemia and vitamin deficiency (*ATC* codes, A11 and B03), cardiovascular disease (*ATC* codes, C01-C10), psychiatric disorders (*ATC* codes, N05-N06), and antiasthmatics (*ATC* code, R03; eTable 1 available at <http://www.jama.com>).

## RESULTS

At baseline, patients in the surgery group were on average 6.3 kg heavier, 1.3 years younger, more frequently smokers; more often had diabetes; and less likely to have a university degree than the control group (TABLE 1). The relative weight changes for those in the surgery group was a loss of 17% at 10 years, 16% at 15 years, and 18% at 20 years vs a gain of 1% at 10 years, a loss of 1% at 15 years, and a loss of 1% at 20 years among those in the control group.

### Inpatient Care

**Hospitalization Frequency.** Approximately 20% to 25% of surgically treated patients were hospitalized annually during follow-up (excluding the index surgery in year 1). In the 20 years after bariatric surgery, patients used a mean cumulative of 54 hospital days vs 40 days by the control group (adjusted difference, 15; 95% CI, 2-27; *P* = .03; eTable 2). Between years 1 and 6, a higher percentage of surgery patients than controls were admitted annually to inpatient care (FIGURE 1). In the surgery group, the proportion of hospitalized patients decreased and stabilized from years 6 to 16 before increasing again, while it increased in controls from 13% to 24% between years 1 and 20.

**Hospital Days by Year.** During the 4 years before the index date, there were no or negligible between-group differences in mean annual hospital days (FIGURE 2). During year 1 (including the index surgery admission), the mean

accumulated hospital days was 9.4 for surgery patients and 0.9 for controls (adjusted difference, 8.4; 95% CI, 7.8-9.1;  $P < .001$ ). Thereafter the difference decreased, but remained the second (adjusted difference, 1.0; 95% CI, 0.6-1.4;  $P < .001$ ), third (adjusted difference, 0.4; 95% CI, 0.1-0.7;  $P = .02$ ), and fourth year after surgery (adjusted difference, 0.5; 95% CI, 0.1-0.9;  $P = .02$ ). No differences were observed thereafter. Within the surgery group, no differences between surgery types or between open vs laparoscopic procedure were observed beyond year 1 (eFigure 1).

**Hospital Days by Period.** Between years 2 and 6, surgery patients incurred 1.7 mean annual hospital days vs 1.2 among controls, respectively (adjusted difference, 0.5; 95% CI, 0.2-0.7;  $P < .001$ ; TABLE 2). Between years 7 and 20, no difference was observed.

### Nonprimary Outpatient Care

**Visit Frequency.** The percentage of patients with 1 or more annual nonprimary care outpatient visits was higher than for inpatient care, but otherwise followed a similar pattern with greater use in surgery patients than in controls for about 5 years (Figure 1). In both groups, the percentage of patients with annual visits generally increased over time.

**Number of Visits by Year.** Similar to the finding for hospital days, the annual mean for nonprimary care outpatient visits was higher in surgery patients than in controls during years 2 to 4, with no differences thereafter (FIGURE 3). For visits with diabetes, cardiovascular disease, or tumors as main diagnosis (conditions for which we have previously demonstrated beneficial effects of surgery<sup>8,10-12</sup>), the annual mean was lower in surgery patients than in controls between years 6 and 15 (eFigure 2).

**Number of Visits by Period.** From years 2 to 6, patients who underwent surgery incurred a mean annual nonprimary care outpatient visits of 1.3 vs 1.1

**Table 1.** Patient Characteristics at Baseline

	Surgery (n = 2010)	Controls (n = 2037)	P Value
Women, No. (%)	1420 (71)	1447 (71)	.79
Age, mean (SD), y	47 (6)	49 (6)	<.001
Height, mean (SD), cm	169 (9)	169 (9)	.64
Women	165 (6)	165 (6)	.59
Men	179 (7)	180 (7)	.34
Weight, mean (SD), kg	121 (17)	115 (17)	<.001
Women	116 (14)	111 (15)	<.001
Men	133 (17)	125 (17)	<.001
Body mass index, mean (SD) <sup>a</sup>	42.4 (4.5)	40.1 (4.7)	<.001
Women	42.8 (4.3)	40.7 (4.6)	<.001
Men	41.3 (4.8)	38.6 (4.7)	<.001
Waist circumference, mean (SD), cm	126 (11)	120 (11)	<.001
Women	124 (10)	119 (11)	<.001
Men	131 (11)	124 (11)	<.001
University education, No. (%)	257 (13)	431 (21)	<.001
Smoking, No. (%)	518 (26)	422 (21)	<.001
Diabetes, No. (%) <sup>b</sup>	345 (17)	262 (13)	<.001

<sup>a</sup>Calculated as weight in kilograms divided by height in meters squared.

<sup>b</sup>Based on blood glucose, use of antidiabetic medication, or both.

among control patients (adjusted difference, 0.3; 95% CI, 0.1-0.4;  $P = .003$ ; Table 2). From years 7 to 20, no difference was observed.

### Drug Costs

**Overall Drug Costs.** Nearly all patients had 1 or more drugs dispensed annually during the follow-up years for which we had registry data (years, 7-20). Overall drug costs were lower in surgery patients than in controls for 8 of the 14 years investigated, and point estimates were consistently lower (FIGURE 4). Averaging over the 7- to 20-year period, surgery patients incurred an annual mean cost of US \$930 and controls, US \$1123 (adjusted difference -\$228, 95% CI -\$335 to -\$121;  $P < .001$ ; Table 2).

**Drug Cost Distribution.** Consistently lower costs were observed in surgery patients than in control patients for antidiabetic and anti-cardiovascular disease agents (except for year 8 due to an outlier with pulmonary hypertension who was taking bosentan; FIGURE 5). Asthma drug costs were lower in surgery patients than controls from year 7 to year 11, whereas drug costs associated with anemia and

vitamin deficiencies were higher from year 7 to year 10. Few differences were seen for gastrointestinal and psychiatric drug costs, although the point estimates were generally greater for the surgery group.

### Adverse Events

Within 90 days from study start, 5 of 2010 patients (0.2%) in the surgery group and 2 of 2037 patients (0.1%) in the control group had died. As reported elsewhere, out of 1164 surgically treated patients, 151 (13%) experienced 193 postoperative complications.<sup>10</sup>

### COMMENT

Although the study patients mostly received vertical-banded gastroplasties, an operation that is no longer commonly performed, they achieved a high degree of weight loss that was sustained for many years. They had a 20-kg greater weight loss than non-surgery controls. Despite the weight loss, surgically treated patients used more health care resources both on an inpatient and outpatient basis in the first 6-year period after surgery. Beyond that, use between groups was



the same. Drug costs were lower in surgery patients than in the controls between years 7 to 20. These differences were attributable to lower costs for treating diabetes and cardiovascular disease.

A recent meta-analysis of the association between bariatric surgery, weight loss, operative mortality, and comorbidities highlighted the paucity of long-term outcomes for bariatric sur-

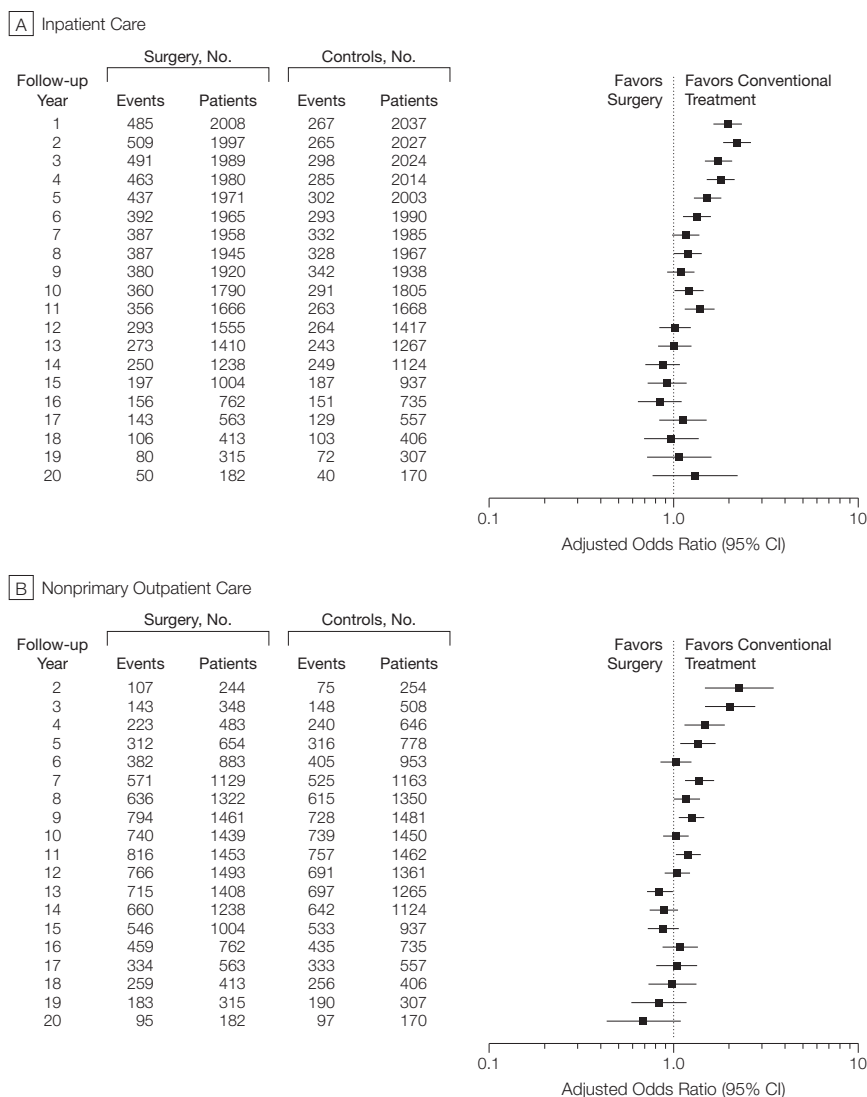
gery.<sup>6</sup> Another review of bariatric surgery by the National Institute of Clinical Excellence (NICE) in the United Kingdom, concluded that long-term studies were needed to provide data on “resource use across the entire patient pathway to develop robust costings” for economic evaluations.<sup>20</sup> Consequently, we used the Swedish Obese Subjects study to determine health care use following bariatric surgery because it is the

only multicenter, prospective, long-term study of bariatric surgery with very good matching between groups.

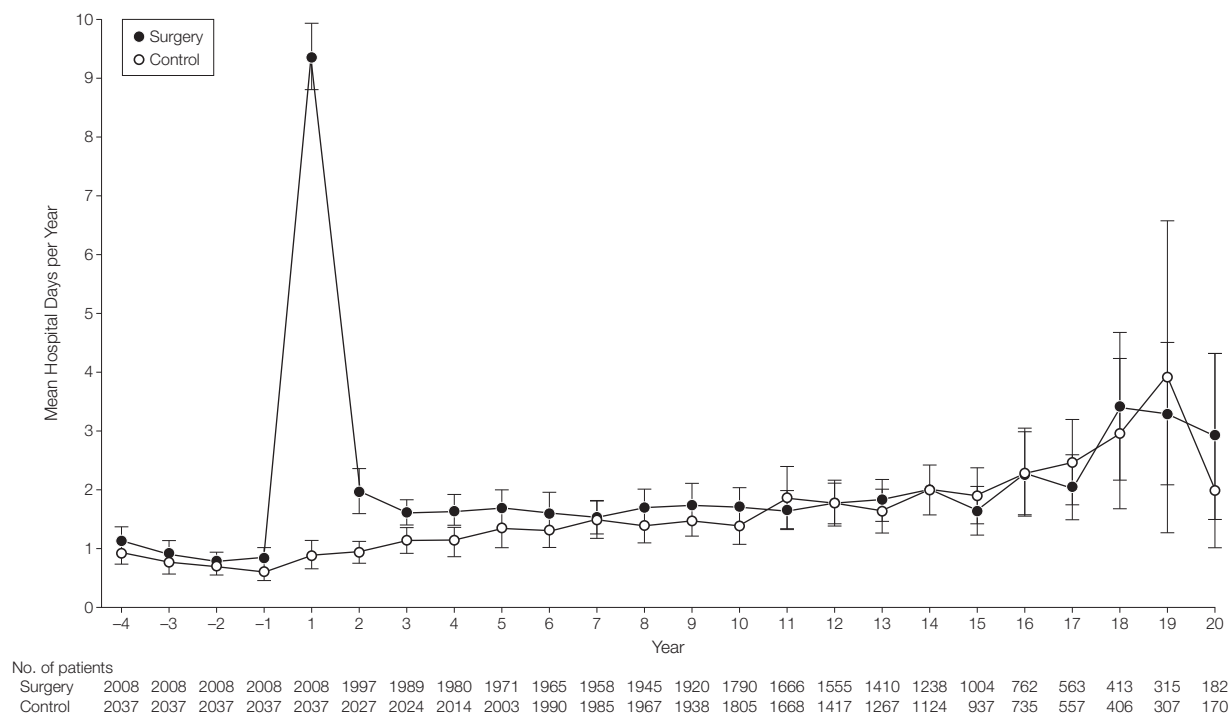
Our results were similar to an observational study from California showing increased hospitalizations of bariatric surgery patients for up to 5 years after surgery.<sup>21</sup> A Canadian study reported health care cost savings over 5 years vs age- and sex-matched obese controls.<sup>22</sup> Controls in that study were identified via ICD-9 codes for morbid obesity in a health insurance claims database. This might bias the cohort in favor of patients with a greater disease burden. This appears to be true since their control group had a worse prognosis than ours<sup>9</sup> and a worse prognosis than that observed in another controlled cohort study.<sup>23</sup>

We previously reported that the surgery group had more hospital days than did controls over 6 years based on 481 surgery patients and 481 controls.<sup>24</sup> The current study adds the information that nonprimary care outpatient visits were higher during this period. We now report beyond 6 years that inpatient and outpatient resource use is the same between groups. We had also reported self-reported medication use patterns for a sample (n=510, surgery; n=455, controls) of the Swedish study population for the first 6 years.<sup>25</sup> The current study of the entire cohort using pharmacy dispensing data confirms some of the 6-year results and extends the observations to 20 years. At years 7 through 20, there were lower overall drug costs for surgery patients than for controls. These differences were attributable to savings for medications that treat diabetes and cardiovascular disease. In contrast, our previous study was using self-reported data for the first 6 years, no savings were identified because savings on medication for diabetes and cardiovascular disease were offset by increased use of gastrointestinal medications and vitamins.<sup>25</sup> In the current study using pharmacy rather than self-reported data, we found significantly less medication use by bariatric surgery patients for the 7- through 20-year period. At the same time, it appears

**Figure 1.** Adjusted Odds Ratio for Percentage of Any Annual Inpatient or Nonprimary Outpatient Care Visits



Inpatient care excludes the index surgery admission during year 1 (the index year). Adjusted for baseline age, smoking, diabetes status, body mass index, inclusion period (before 1995 or 1995 and beyond), and for the in-patient care analysis) annual hospital day the year prior to the index date.

**Figure 2.** Mean Annual Hospital Days From 4 Years Before to 20 Years After the Index Date

Error bars indicate 95% CIs. Registry data are from 1983-2009; year 1 is the index year.

**Table 2.** Annual Hospital Days, Nonprimary Care Outpatient Visits, and Drug Costs by Follow-up Period in Relation to the Index Date

Outcome, Data Capture	No. of Patients	Median Years of Follow-up (IQR)	Weighted Median per Year (IQR)	Weighted Mean per Year (95% CI)	Adjusted Mean Difference (95% CI) <sup>a</sup>	P Value
Hospital days, 1987-2009						
Year 1 (index year)						
Surgery	2008	1.0 (1.0 to 1.0)	7 (5 to 9)	9.4 (8.8 to 9.9)	8.4 (7.8 to 9.1)	<.001
Controls	2037	1.0 (1.0 to 1.0)	0 (0 to 0)	0.9 (0.6 to 1.1)		
2-6 y						
Surgery	1997	5.0 (5.0 to 5.0)	0.6 (0 to 1.6)	1.7 (1.5 to 1.9)	0.5 (0.2 to 0.7)	<.001
Controls	2027	5.0 (5.0 to 5.0)	0 (0 to 1)	1.2 (1.0 to 1.3)		
7-20 y						
Surgery	1958	9.1 (6.7 to 11.4)	0.6 (0 to 1.6)	1.8 (1.6 to 2.0)	0.0 (-0.3 to 0.3)	.95
Controls	1985	8.8 (5.7 to 11.3)	0.4 (0 to 1.6)	1.8 (1.6 to 1.9)		
Nonprimary care outpatient visits, 2001-2009						
2-6 y						
Surgery	887	3.1 (1.9 to 4.7)	0.8 (0 to 1.8)	1.3 (1.2 to 1.5)	0.3 (0.1 to 0.4)	.003
Controls	964	3.3 (2.3 to 4.3)	0.5 (0 to 1.4)	1.1 (1.0 to 1.2)		
7-20 y						
Surgery	1936	8.6 (6.5 to 9.0)	1.2 (0.6 to 2.3)	1.8 (1.6 to 2.0)	-0.2 (-0.4 to 0.1)	.12
Controls	1962	8.2 (5.7 to 9.0)	1.1 (0.4 to 2.4)	1.9 (1.8 to 2.1)		
Drug cost, US \$, 2005-2011						
7-20 y						
Surgery	1889	5.9 (5.2 to 5.9)	529 (177 to 1171)	930 (860 to 1001)	-228 (-335 to -121)	<.001
Controls	1893	5.9 (5.2 to 5.9)	626 (225 to 1435)	1123 (1040 to 1206)		

Abbreviation: IQR, interquartile range.

<sup>a</sup>Adjusted for age, sex, baseline body mass index, baseline diabetes, smoking status, inclusion period (before 1995 or 1995 and beyond), and (for the hospitalization analysis) annual hospital days the year prior to the index date. The analysis was weighted by person-years under observation in the respective time periods.

to reflect the pattern for health care use, which was elevated in the surgery group during the 6-year period after the index date (when there was no difference in drug costs<sup>25</sup>), and then showed no differences from year 7 to 20 (when drug cost savings were observed in our current analysis).

After the index year of the procedure, the difference in annual hospital days decreased between surgery and control patients until year 5 when there were no more differences, a finding that persisted for the remainder of the study. Increased hospital use resulted from complications, anemia, revisional surgery, gallstones, and need for plastic surgery in surgery

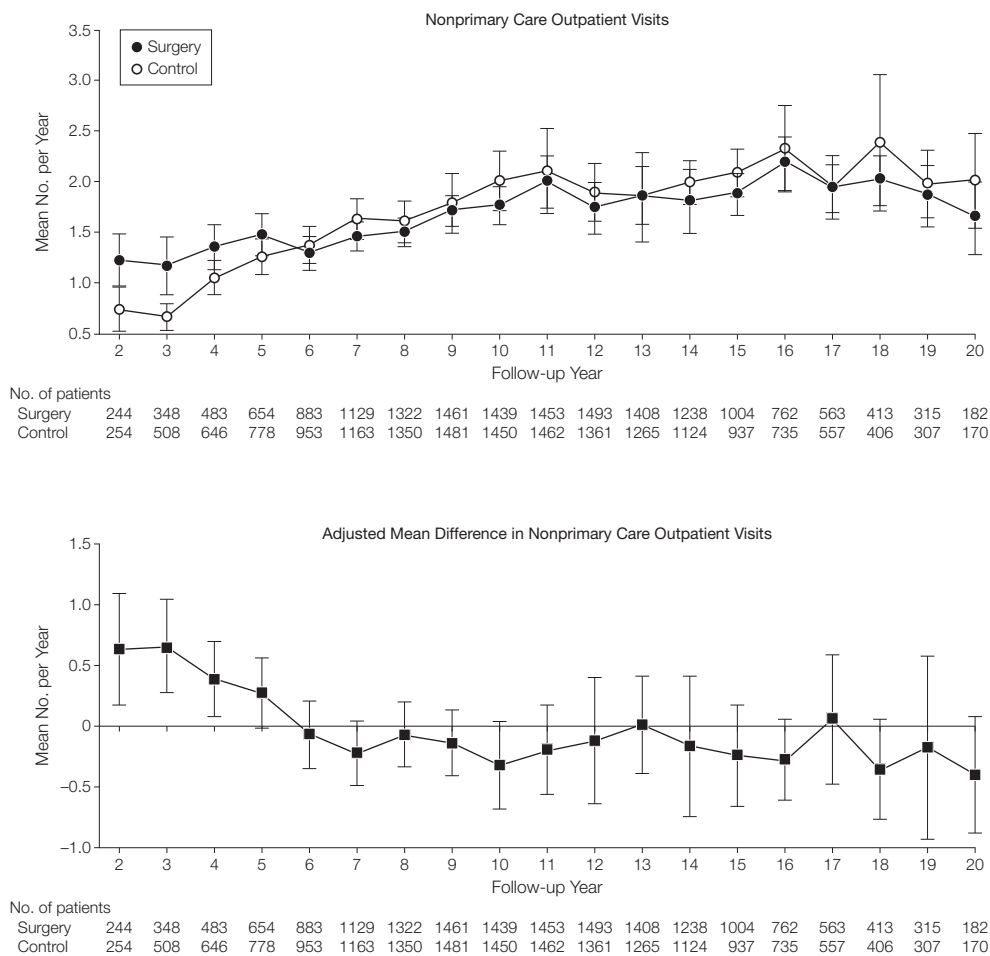
patients as opposed to controls.<sup>25</sup> These conditions probably also resulted in the corresponding increase in nonprimary outpatient care use during the same period.

Bariatric surgery reduced cardiovascular events,<sup>11</sup> cancer,<sup>10</sup> and diabetes.<sup>8,12</sup> Translating these benefits into reduced health care resource use may not be evident for many years because these diseases take many years before they become problematic. In the Swedish Obese Subjects study, improved outcomes for these complications of obesity were observed during 10 to 15 years of follow-up. Given that, there should have been a detectable benefit in

resource use during those periods. However, we did not observe that for overall health care resource use. The 10-year cumulative incidence of cancer was 5.5% and 6.0% for cardiovascular disease events.<sup>10,11</sup> The 20% to 30% benefit in these diseases attributable to bariatric surgery coupled with the low incidence might explain why we did not observe an overall benefit to bariatric surgery in terms of health care resource use during this period.<sup>10,11</sup>

The difference in drug costs was driven by costs for medications for diabetes and cardiovascular disease, reflecting the effects of bariatric surgery on diabetes remission,<sup>8</sup> diabetes

**Figure 3.** Mean Annual Nonprimary Outpatient Care Visits From Year 2 to 20



Adjusted for baseline age, sex, smoking, diabetes status, body mass index, and inclusion period (before 1995 or 1995 and beyond). Error bars indicate 95% CIs. Registry data are from 2001-2009.

prevention,<sup>12</sup> and cardiovascular disease events.<sup>11</sup>

Our findings indicate that bariatric surgery is associated with increased health care use in the first 6 years after surgery.<sup>24,25</sup> Thereafter, inpatient and nonprimary outpatient care use were similar between treatment groups. The surgery group experienced a savings in drug cost between years 7 to 20. Based on our findings, bariatric surgery appears to result in greater health benefits<sup>9-12</sup> than conventional obesity treatment, but at a higher cost over the time of the study. However, a formal cost-effectiveness analysis is needed to quantify the cost-per-unit health effect that is associated with bariatric surgery.

To date, the Swedish Obese Subjects study is the largest and longest prospective, controlled study of bariatric surgery. Although mortality was the primary outcome,<sup>9</sup> health care use data were also collected prospectively. Inpatient data were sourced from the National Patient Register and available for patients after (and before) the index date until death or emigration. Registry-based nonprimary outpatient care and drug dispensing data were available from 2001 and 2005, respectively. Using registry linkage overcomes limitations associated with questionnaire-based data collection such as nonresponse and recall bias. Also, because there is universal health care access in Sweden, utilization is not distorted by insurance status, and likely a reasonable reflection of overall morbidity.

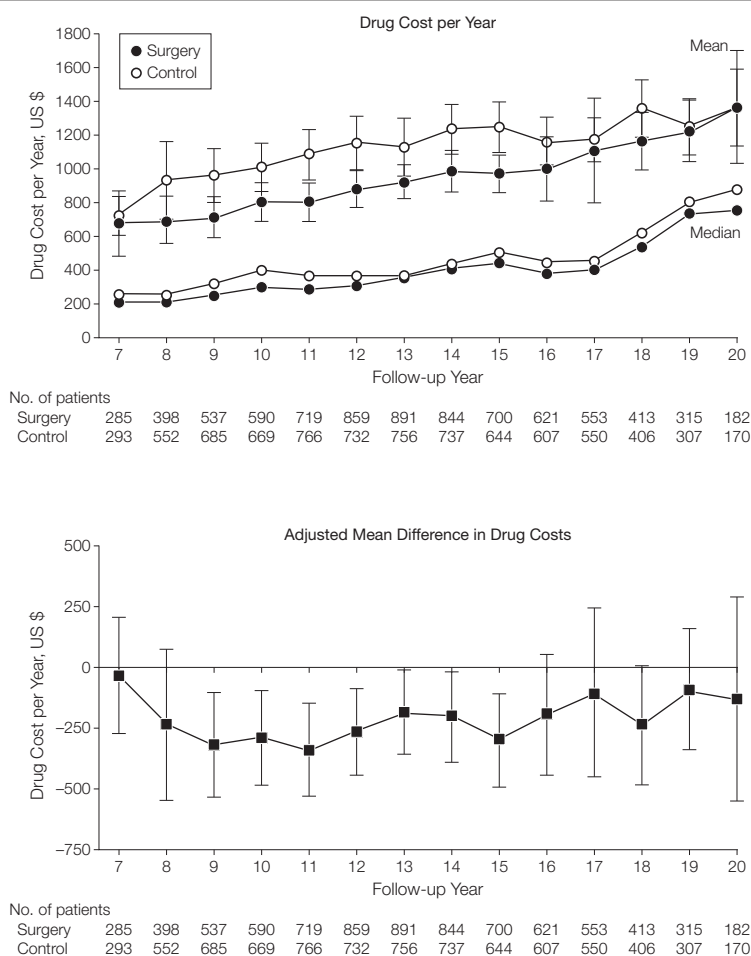
Our study was limited because the ethical review boards did not permit randomization. Therefore selection bias and residual confounding beyond that eliminated by matching and adjustments may exist. Analysis of hospital use before the surgery index date suggested that the groups were similar. Preindex date registry data on the other outcomes are unavailable. Although imbalances existed at baseline, we compensated for them by multivariable adjust-

ment. Another limitation is that there is no natural time point in which to determine that bariatric surgery is more costly and then more beneficial or no different from conventional treatment. We chose to segregate our analysis before and after 7 years based on the availability of data and previous publications rather than on there being some change that should occur at that time.

The patient cohort reported herein underwent surgery between 1987 and 2001. Since then, surgical procedures changed with greater use of laparoscopic techniques and Roux-en-Y gastric bypass procedures. Nev-

ertheless, our cohort had dramatic and sustained weight loss despite the application of now outdated procedures. Patients experienced low post-operative mortality (90-day mortality, 0.25% in surgery patients vs 0.10% in controls,<sup>9</sup> compared with a 30-day mortality of 0.33%<sup>21</sup> and 1.9%<sup>26</sup> in 2 US studies). Although the procedures differ from contemporary operations, it is likely that the results from our study are typical of those that might be expected from other procedures that result in similar weight loss outcomes with similar perioperative adverse event profiles.

**Figure 4.** Mean and Median Annual Prescription Drug Costs From Year 7 to 20 (Registry Data 2005-2011)



Adjusted for baseline age, sex, smoking, diabetes status, body mass index, and inclusion period (before 1995 and 1995 and beyond). Error bars indicate 95% CIs.



We were limited in not having registry data for primary care visits. Also, the Prescribed Drug Registry contains all prescription drugs dispensed from pharmacies, but not in-hospital drug use.

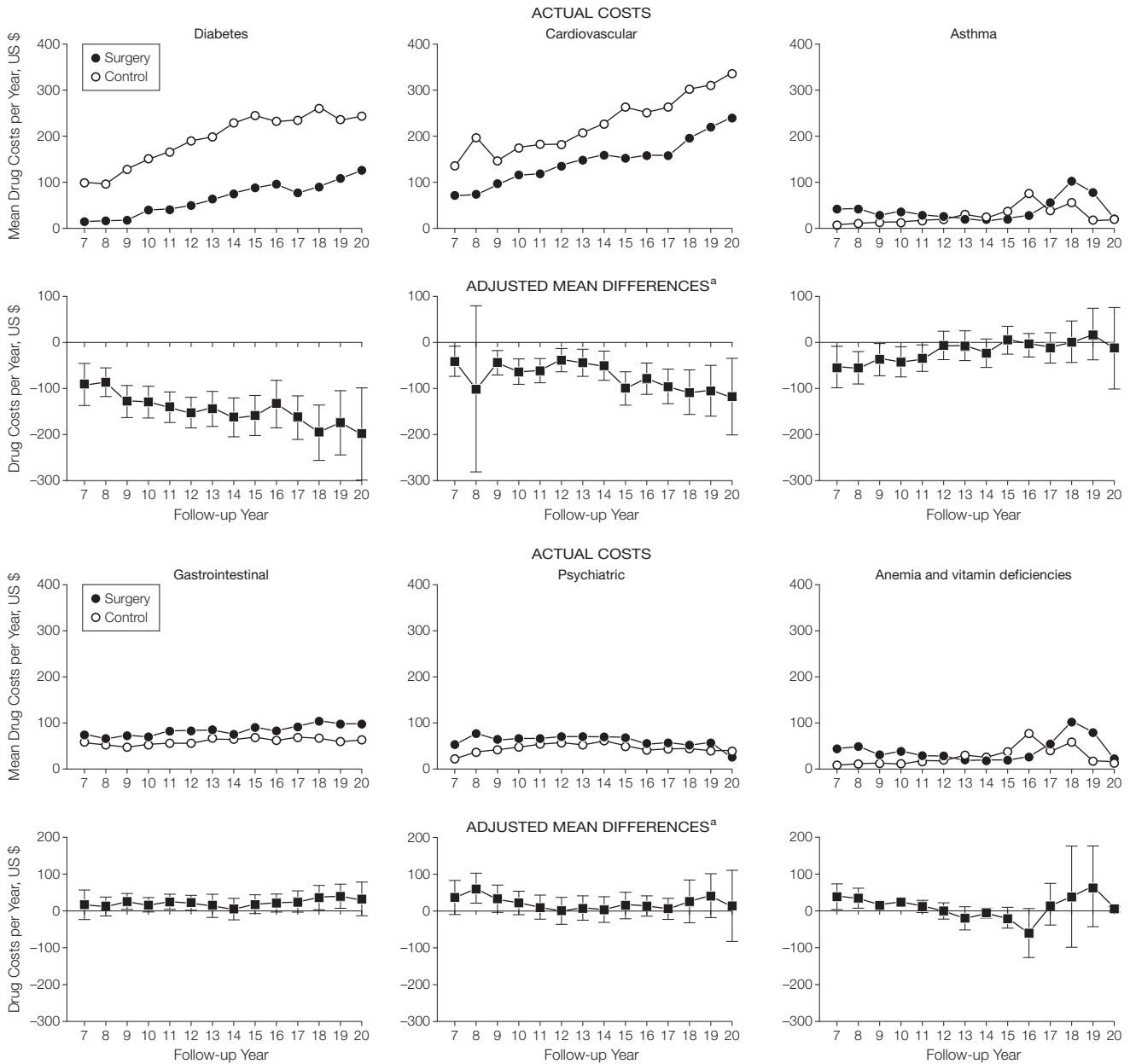
Although we had inpatient hospitalization information for nearly all patients for 10 or more years, we did not

have similar information for nonprimary outpatient visits and dispensed drugs because no registries for these services existed when recruitment started in 1987. Therefore, fewer patients were available for nonprimary care outpatient visits and drug costs in the first few years after surgery.

**CONCLUSIONS**

Despite considerably greater and sustained weight loss than conventionally treated controls, surgically treated patients used more inpatient and nonprimary outpatient care during the 6-year period after the index date but not thereafter. Cost savings

**Figure 5.** Mean Annual Prescription Drug Costs From Year 7 to 20 for Selected Drug Groups (Registry Data 2005-2011)



<sup>a</sup>Adjusted for baseline age, sex, smoking, diabetes status, body mass index, and inclusion period (before 1995 and 1995 and beyond). Error bars indicate 95% CIs. Sample sizes are the same as those in Figure 4.

in the surgery group were seen for medications that treat diabetes and cardiovascular disease between year 7 and 20, resulting in lower overall drug costs during that period.

**Author Contributions:** Drs Narbro and Neovius 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. Drs Sjöström and Carlsson contributed equally and are both guarantors. **Study concept and design:** Carlsson, Keating, Narbro, Neovius, Peltonen, Sjöholm, Sjöström, Ågren **Acquisition of data:** Carlsson, Narbro, Neovius (registry data only), Peltonen, Sjöholm, Sjöström **Analysis and interpretation of data:** Carlsson, Keating, Narbro, Neovius, Peltonen, Sjöholm, Sjöström **Drafting of the manuscript:** Carlsson, Keating, Narbro, Neovius, Peltonen, Sjöholm, Sjöström **Critical revision of the manuscript for important intellectual content:** Carlsson, Keating, Narbro, Neovius, Peltonen, Sjöholm, Sjöström, Ågren **Statistical analysis:** Neovius **Obtained funding:** Carlsson, Narbro, Neovius, Sjöström

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**Study supervision:** Carlsson, Sjöström

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