Pharmaceutical Costs in Obese Individuals

Comparison With a Randomly Selected Population Sample and Long-term Changes After Conventional and Surgical Treatment: The SOS Intervention Study

Kristina Narbro, PhD; Göran Ågren, MD; Egon Jonsson, PhD; Ingmar Näslund, MD, PhD; Lars Sjöström, MD, PhD; Markku Peltonen, PhD

Background: Obesity is associated with increased morbidity rates and pharmaceutical costs. To what extent various medication costs are affected by intentional weight loss is unknown.

Methods: A cross-sectional comparison of the use of prescribed pharmaceuticals was conducted in 1286 obese individuals in the Swedish Obese Subjects (SOS) intervention study and 958 randomly selected reference individuals. Medication changes for 6 years after bariatric surgery were evaluated in 510 surgically and 455 conventionally treated SOS patients.

Results: Compared with the reference group, obese individuals were more often taking diabetes mellitus, cardiovascular disease, nonsteroidal anti-inflammatory and pain, and asthma medications (risk ratios ranging from 2.3-9.2). Average annual costs for all medications were 1400 Swedish kronor (SEK) (US $140) in obese individuals and 800 SEK (US $80) in the reference population ($P<.001$). Average yearly medication costs during follow-up were 1849 (US $185) in surgically treated patients (weight change −16%) and 1905 SEK (US $190) in weight-stable conventionally treated patients ($P=.87$). The surgical group had lower costs for diabetes mellitus (difference: −94 SEK/y (−US $9)) and cardiovascular disease medications (difference: −186 SEK/y (−US $19)) but higher costs for gastrointestinal tract disorder (difference: +135 SEK/y [US $13]) and anemia and vitamin deficiency medications (difference: +50 SEK/y [US $5]).

Conclusions: Use and cost of medications are markedly increased in obese vs reference populations. Surgical obesity treatment lowers diabetes mellitus and cardiovascular disease medication costs but increases other medication costs, resulting in similar total costs for surgically and conventionally treated obese individuals for 6 years.

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Obesity is associated with elevated morbidity and mortality rates. The prevalence of type 2 diabetes mellitus, hypertension, gallbladder disease, and osteoarthritis and the proportion of individuals with 2 or more obesity-related comorbidities increase with increasing weight. The high morbidity rate and the associated increased drug use among obese persons are costly for society and the individual. It has been estimated that 1% to 6% of the health care expenses in affluent countries are attributable to obesity and that approximately 30% of these costs are pharmaceutical costs for treating obesity-related disorders.

Intentional weight loss in the obese population can reduce cardiovascular risk factors and the associated use of medication, although the long-term effects on hypertension have recently been questioned. Few studies have calculated the effect of weight loss on pharmaceutical costs for specific obesity-related diseases. Recently, we reported a long-term reduction in the use of diabetes mellitus and cardiovascular disease (CVD)-related medications after maintained weight loss for 6 years in the obese population. In the present study, we compare the use and cost of prescribed medications in the obese population with a random sample of the general population and provide estimates for changes in the use and total cost of prescribed medications for 6 years after surgical treatment for obesity, based on data from the Swedish Obese Subjects (SOS) controlled intervention trial. Our hypotheses are that the obese population has elevated medication costs compared with the general population and that obesity surgery and weight reduction can reduce medication costs in the obese population.
SOS STUDY

The SOS project is an ongoing nationwide intervention trial of obesity that began in 1987.²¹ The primary aim is to determine whether mortality and morbidity rates in obese persons can be reduced by surgical treatment and weight reduction. The SOS project consists of 2 parts: a cross-sectional registry study and a controlled, prospective intervention study. A (so far) cross-sectional population study of randomly selected individuals from the general population is also affiliated with the project.

The registry study consisted of a survey of 6328 obese persons including extensive questionnaires and a health examination at primary health care centers. In the intervention study, 2010 surgically treated obese patients will be compared for 20 years with a control group of 2037 matched obese patients who are offered conventional treatment at their primary health care centers. The study involves 480 primary health care centers and 25 surgical departments throughout Sweden. The inclusion criteria for the intervention study were age 37 to 60 years and body mass index (BMI; calculated as weight in kilograms divided by the square of height in meters) of 34 or greater for men and 38 or greater for women. The exclusion criteria were previous bariatric surgery; previous gastric operations; gastric or duodenal ulcer in the past 6 months; active malignancy in the past 5 years; myocardial infarction in the past 6 months; a bulimic eating pattern; abuse of alcohol, narcotics, or psychopharmaceutical drugs; psychosocial problems suspected to result in poor cooperation; regular use of cortisone or nonsteroidal anti-inflammatory drugs (NSAIDs); and other severe illnesses.

Patients who were interested in surgery and met the inclusion but not the exclusion criteria were invited to discuss bariatric surgery with a surgeon. Individuals who subsequently accepted surgery formed the surgical group and were treated with gastric banding, gastric bypass, or vertical banded gastroplasty according to the local practice at the surgical department concerned.²² The conventionally treated control group was selected from eligible patients in the registry study by using a computerized matching procedure, taking into account sex and 18 matching variables related to morbidity and mortality. The matching procedure was designed to make the mean values of the matching variables as similar as possible in the 2 treatment groups. The variables used in the matching procedure, apart from sex, were age, height, weight, waist and hip circumferences, waist-hip ratio, systolic blood pressure, total serum cholesterol level, triglyceride levels, smoking, diabetes mellitus, premenopausal/postmenopausal state among women, 4 psychosocial variables related to mortality, and 2 personality traits related to treatment preferences. Patients in the control group receive the same treatment as obese patients in general at different primary care centers, which could include dietary advice, behavior modification, a very-low-calorie diet, and physical training, or no treatment at all, according to local practices.

Follow-up visits are performed by outpatient appointments and dispatched questionnaires at 6 months and 1, 2, 3, 4, 6, 8, 10, 15, and 20 years after inclusion. Enrollment of patients into the registry and intervention studies was completed in January 2001.

The SOS reference study is a population study conducted in the county of Mölndal in southern Sweden during 1994 to 1999.²³ A random sample of 1752 men and women aged 37 to 60 years was selected from the population registry. The reference population was examined by using identical questionnaires and a health examination similar to participants in the SOS registry study. Follow-up examinations are planned after 10, 15, and 20 years.

PRESENT STUDY

To estimate the use and cost of medications in an obese population in relation to that of a general population, we performed a cross-sectional investigation comparing baseline data on the use and cost of medications from the first 1294 consecutive patients (surgically and conventionally treated patients) combined in the SOS intervention study with corresponding data from baseline examinations in the reference study. Data on medications were available for 958 individuals (54.7%) in the reference population and for 1286 (99.4%) in the SOS intervention study.

To estimate the effect of surgical treatment and weight reduction on the use and cost of medications for 6 years, a longitudinal comparison was undertaken on the first 647 surgically treated patients and the first 647 conventionally treated patients from the SOS intervention study. These 1294 patients, included between 1987 and 1992, are the same as those used in the comparison with the reference study previously mentioned. Only individuals with complete 6-year follow-up were included in this comparison (n=969). Owing to mortality and dropouts, the 6-year data were not available for 137 patients (21.2%) in the surgical group and 192 (29.7%) in the conventionally treated group.

The SOS projects are approved by the ethics committees of all universities in Sweden, and all participants gave their consent to participate. The study is being conducted in accordance with the Declaration of Helsinki as amended.²⁷

MEASUREMENTS

Body weight, rounded to the nearest 0.1 kg, was measured with participants wearing indoor clothing and no shoes. Height was measured with participants not wearing shoes and was rounded to the nearest 0.1 m. Information on prescribed medications, including dosage and strength, was collected from questionnaires filled out by all participants at inclusion in the SOS reference and intervention studies. In the questionnaire, individuals were asked to "list here the brand name, strength, and number of tablets or milliliters per day of all prescribed drugs that you have taken regularly during the past 3 months." The same questionnaires were used at the 6-month and 1-, 2-, 3-, 4-, and 6-year follow-up visits in the SOS intervention study. Temporary medications were excluded, and 1 person in the intervention study was excluded from the cost calculations because of extreme costs for cancer medications. All drugs were classified according to the Anatomic Therapeutic Classification (ATC) system, and 8 drug categories were defined:

- Diabetes mellitus: ATC group A10 (drugs used in diabetes mellitus).
- Cardiovascular disease: ATC groups C01 (cardiac therapy), C02 (antihypertensives), C03 (diuretics), C07 (B-adrenergic blocking agents), C08 (calcium channel blockers), and C09 (agents acting on the renin-angiotensin system).
- Muscle inflammation, rheumatic disorders, and pain (NSAIDs/pain): ATC groups M01A (anti-inflammatory and antirheumatic products, nonsteroids), M03 (muscle relaxants), N02A (opioids), and N02B (other analgesics and antipyretics).
- Asthma: ATC group R03 (antiasthmatics).
- Psychiatric disorders: ATC groups N05 (psycholopics) and N06 (psychoanaleptics).
- Anemia and vitamin deficiency (anemia): ATC groups A11 (vitamins) and B03 (antianemic preparations).
- Gastrointestinal tract disorders (GID): ATC groups A02 (an- acids and drugs for treatment of peptic ulcer and flatulence), A03 (antispasmodic and anticholinergic agents and propulsives), A04 (antiemetics and antinauseants), A05 ( bile and liver
therapy), A06 (laxatives), and A07 (antidiarrheals and intestinal anti-inflammatory/anti-infective agents).
• Other: all other prescribed drugs.

The individual daily costs were calculated for each specific drug and dosage according to the 1997 official price list of the National Corporation of Swedish Pharmacies. When necessary because of deregistration of drugs, an earlier price list was used and the prices were converted into 1997 price levels by means of the Swedish consumer price index.

In the questionnaires, participants were asked about drug use during the previous 3 months. Assuming that use of medications was the same for the whole period covered by the questionnaire (years −1 to 0, 0 to 0.5, 0.5 to 1, 1 to 2, 2 to 3, 3 to 4, and 4 to 6), the daily costs were summed for each drug and individual to estimate the drug-specific medication cost for each period. To estimate the average yearly cost during 6-year follow-up after obesity treatment, a weighted average of the period costs was calculated. All costs are reported in Swedish kronor (SEK) using the following exchange rate from August 2001: 1 SEK = US $0.10 and 0.11 Euro.

STATISTICAL ANALYSES

Differences in the proportion of participants taking medications between the SOS intervention study and the reference population were analyzed in a generalized linear model for the binomial family.28 We report unadjusted proportions and confidence intervals (CIs) based on bootstrap percentiles.29 The number of bootstrap samples was set at 1000. For the surgically and conventionally treated groups in the SOS intervention study, differences in the use and costs of medication were analyzed separately for patients receiving and not receiving the respective medications at baseline and for all participants combined. The data were analyzed using a statistics package (Stata, release 6.0; Stata Corp, College Station, Tex).

RESULTS

CROSS-SECTIONAL COMPARISON OF THE OBESE AND RANDOMLY SELECTED REFERENCE POPULATIONS

The clinical characteristics at baseline for the 1286 obese patients (mean BMI, 41.0) in the SOS intervention study and the 958 randomly selected reference individuals (mean BMI, 25.0) from the SOS reference study are given in Table 1. The reference group had a higher proportion of men and higher age compared with the obese group. Fifty-two percent of the obese and 36% of the randomly selected individuals were taking prescribed medications (P<.001), and the average cost during 1 year for this medication was markedly higher (77%) in the obese group (1387 vs 783 SEK; P<.001).

Compared with the randomly selected reference group, the obese patients in the SOS intervention study were more often taking diabetes mellitus, CVD, NSAIDs/pain, and asthma medications (Table 2). The risk ratio of having medications for these conditions varied between 2.3 and 9.2 in the obese group compared with the reference group. Accordingly, the average yearly costs of these medication groups were markedly higher in obese individuals (Table 2). None of the other medication groups showed statistically significant differences in costs between groups.

In the obese population, the most expensive drug group, measured as average yearly cost per person, was CVD (457 SEK), followed by the groups other medication (298 SEK) and diabetes medications (227 SEK). The lowest costs were for the drug groups psychiatric disorders (99 SEK) and anemia (7 SEK). In the reference population, the average annual cost was highest for the drug group other medication (298 SEK). High costs were also seen for the drug groups GID (144 SEK), psychiatric disorders (141 SEK), and CVD (131 SEK).

THE LONGITUDINAL SOS INTERVENTION STUDY

Baseline Weight and Weight Changes

Table 3 gives the baseline characteristics of the 965 obese patients who completed the 6-year follow-up in the SOS
intervention study. There were no baseline differences between the completers (Table 3) and the 321 noncompleters (these being part of the 1286 individuals reported in Table 1) with respect to the proportion of men, age, or BMI, but the proportion of smokers was higher among noncompleters (32.8% vs 24.4%; \(P = .004\)).

The surgically treated group had a somewhat lower age and a higher BMI than the conventionally treated group (Table 3). During follow-up, the surgically treated group reached a maximum weight loss of 25% after 1 year, whereas there were no changes in the mean body weight in the conventionally treated group. After 6 years, the relative weight change was +1% in the conventionally treated group and \(-16\%\) in the surgically treated group (Figure 1).

**Table 2. Proportion Taking Medications and Average Cost of Medications in Obese Individuals in the SOS Intervention Study Compared With the Reference Population**

<table>
<thead>
<tr>
<th>Medication Group</th>
<th>Diabetes Mellitus</th>
<th>CVD</th>
<th>NSAIDs/Pain</th>
<th>Asthma</th>
<th>PD</th>
<th>Anemia</th>
<th>GID</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking medication, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOS intervention group</td>
<td>6.1</td>
<td>27.8</td>
<td>10.8</td>
<td>5.2</td>
<td>7.2</td>
<td>1.3</td>
<td>4.4</td>
<td>20.5</td>
</tr>
<tr>
<td>Reference group</td>
<td>0.7</td>
<td>8.2</td>
<td>4.1</td>
<td>2.3</td>
<td>4.6</td>
<td>1.6</td>
<td>3.5</td>
<td>23.6</td>
</tr>
<tr>
<td>Risk ratio (95% CI)†</td>
<td>9.2 (4.2-20.0)</td>
<td>4.1 (3.3-5.1)</td>
<td>2.9 (2.0-4.1)</td>
<td>2.3 (1.4-3.8)</td>
<td>1.4 (1.0-2.0)</td>
<td>0.8 (0.4-1.5)</td>
<td>1.3 (0.8-1.9)</td>
<td>0.8 (0.7-1.0)</td>
</tr>
<tr>
<td>Cost, SEK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOS intervention group</td>
<td>107</td>
<td>457</td>
<td>148</td>
<td>155</td>
<td>99</td>
<td>77</td>
<td>177</td>
<td>227</td>
</tr>
<tr>
<td>Reference group</td>
<td>18</td>
<td>131</td>
<td>50</td>
<td>64</td>
<td>141</td>
<td>5</td>
<td>144</td>
<td>298</td>
</tr>
<tr>
<td>Difference (95% CI)†</td>
<td>94 (51-141)</td>
<td>384 (311-454)</td>
<td>100 (64-137)</td>
<td>91 (17-164)</td>
<td>-55 (-129 to 7)</td>
<td>1 (-5 to 6)</td>
<td>34 (-59 to 136)</td>
<td>-69 (-162 to 20)</td>
</tr>
</tbody>
</table>

*SOS indicates Swedish obese subjects; CVD, cardiovascular disease; NSAIDs, nonsteroidal anti-inflammatory drugs; PD, psychiatric disorders; GID, gastrointestinal tract disorders; CI, confidence interval; and SEK, Swedish kronor.
†Adjusted for sex, age, and smoking.

**Table 3. Baseline Characteristics of Surgically and Conventionally Treated Obese Individuals With Complete 6-Year Follow-up in the SOS Intervention Study**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Surgical</th>
<th>Conventional</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals included, total No.</td>
<td>647</td>
<td>647</td>
<td>1294</td>
</tr>
<tr>
<td>Individuals with complete 6-y follow-up, No.</td>
<td>510</td>
<td>455</td>
<td>965</td>
</tr>
<tr>
<td>Taking medications at baseline</td>
<td>262</td>
<td>220</td>
<td>482</td>
</tr>
<tr>
<td>Not taking medications at baseline</td>
<td>248</td>
<td>235</td>
<td>483</td>
</tr>
<tr>
<td>Men, %</td>
<td>31.0</td>
<td>31.0</td>
<td>31.0</td>
</tr>
<tr>
<td>Age at inclusion, mean (SD), y</td>
<td>47.1 (5.8)</td>
<td>48.6 (6.1)</td>
<td>47.8 (6.0)</td>
</tr>
<tr>
<td>BMI at inclusion, mean (SD), kg/m²</td>
<td>41.8 (4.1)</td>
<td>39.9 (4.6)</td>
<td>40.9 (4.4)</td>
</tr>
</tbody>
</table>

*SOS indicates Swedish obese subjects; BMI, body mass index.

The total cost of medications per person and year increased from 1386 to 2607 SEK during the 6 years of follow-up in the surgically treated group and from 1261 to 2633 SEK in the conventionally treated group (adjusted difference in change, \(-88\) SEK; 95% CI, \(-595\) to \(-418\) SEK) (Figure 2). The average yearly total cost during the 6 years of follow-up was similar in surgically (1849 SEK) and conventionally (1905 SEK) treated participants (Table 4). To eliminate the possible direct, short-term effects of bariatric surgery and other obesity treatments on medication, we excluded the costs during the first year after inclusion in the intervention study and calculated average yearly costs during years 2 to 6 of follow-up. The results were similar in that there were no clear differences between the treatment groups: the average yearly cost was 1950 SEK in the surgical group and \(-43\) SEK in the conventionally treated group (adjusted difference, \(-43\) SEK; 95% CI, \(-347\) to 235 SEK).

**Drug-Specific Costs at Baseline and During Follow-up**

Costs for specific drug groups during the year preceding inclusion in the study are given in Table 5. The cost for diabetes mellitus medication was higher in the surgical group (adjusted difference, 97 SEK; 95% CI, 11-205 SEK) compared with the conventionally treated group. Costs for the other medication groups did not differ significantly between treatment groups.

Average drug-specific costs for 6 years of follow-up are given in Table 5. Surgically treated patients had markedly lower average yearly costs for diabetes mellitus (\(-69\%)\) and CVD (\(-31\%)\) medications but higher costs than conventionally treated obese patients for the drug groups GID and anemia.
Change in Proportion of Participants Taking and Not Taking Medication

Of obese individuals taking any medications at baseline, the surgically treated group had a lower proportion taking medications at all follow-up times starting at year 1 compared with the conventionally treated group (Figure 3). After 6 years, 76.7% in the surgically treated group and 90.0% in the conventionally treated group were still taking medications (adjusted risk ratio, 0.90; 95% CI, 0.83-0.97).

Of obese individuals not taking any medications at baseline, the proportion starting medication use increased steadily over time in the conventionally treated group (Figure 3). Except for a transient spike in consumption at 6 and 12 months, which was mostly due to a high intake of anemia and vitamin deficiency medications, the development was almost identical in the surgical group. At 6-year follow-up, the proportion of patients taking any type of prescribed drug was 44.8% in the surgically treated group and 43.0% in the conventionally treated group (adjusted risk ratio, 1.10; 95% CI, 0.76-1.60).

Total Costs at Baseline and During Follow-up Among Those Taking and Not Taking Medication at Baseline

Surgically and conventionally treated patients taking medications at baseline had similar total medication costs during the year before study inclusion (Table 4). During follow-up of these individuals, the average yearly medication cost was lower in the surgical group than in the control group, as reflected by the unadjusted difference (–439 SEK; 95% CI, –911 to –90 SEK). When taking into account differences in the baseline levels of age, BMI, sex, and cost of medications, the difference between groups was not statistically significant (adjusted difference, –293 SEK; 95% CI, –807 to 149 SEK).

By definition, patients not taking medications at baseline had no costs during the year before inclusion. The average annual cost for 6 years in these individuals was not statistically significantly different in the surgically (865 SEK) and conventionally (715 SEK) treated groups (adjusted difference, 160 SEK; 95% CI, –115 to 449 SEK) (Table 4).

Drug-Specific Costs During Follow-up in Those Taking and Not Taking Medications at Baseline

Figure 4 gives the average annual costs for 6 years for specific drug groups in individuals taking and not taking medications at baseline. Patients in the surgically treated group who were receiving diabetes mellitus and CVD medications at baseline had significantly lower average costs for these medication groups during follow-up compared with the conventionally treated group (Figure 4A). Furthermore, the costs for asthma and GID medications were higher in the conventionally treated group compared with the surgical group, but these differences did not reach statistical significance (asthma: adjusted difference, –877 SEK; 95% CI, –2304 to 673 SEK; GID: adjusted difference, –970 SEK, 95% CI –2180 to 38 SEK).

Among patients who were not taking medications at baseline, the average annual cost for 6 years for diabetes mellitus (adjusted difference, –52 SEK; 95% CI, –78 to –30 SEK) and CVD (adjusted difference, –105 SEK; 95% CI, –186 to –32 SEK) medications were again lower in the surgically treated group compared with the conventionally treated group (Figure 4B). However, the surgical group had higher average costs for the drug groups NSAIDs/pain, GID, and anemia. The adjusted difference in the average annual costs between groups was 83 SEK (95% CI, 11–166 SEK) for NSAIDs/pain, 160 SEK (95% CI, 56–278 SEK) for GID, and 50 SEK (95% CI, 36–66 SEK) for anemia. As reported previously, the net effect of all differences in Figure 4 resulted in approximately equal annual costs per person for 6 years in surgically (1849 SEK) and conventionally (1905 SEK) treated obese patients.
studies7-9 have estimated the total cost of medications in use of medications in lean and obese individuals and some BMI greater than 30 or 35 was associated with a 55%6 to responding total cost of medications in lean and obese in-

edge, have measured total use and calculated the corre-

lation, even after substantial and sustained weight re-

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Table 4. Average Yearly Cost During the Year Before Inclusion and for 6 Years of Follow-up in 509* Surgically and 455 Conventionally Treated Obese Individuals in the SOS Intervention Study for All Prescribed Drugs Combined†

<table>
<thead>
<tr>
<th></th>
<th>Surgical Group</th>
<th>Conventional Group</th>
<th>Difference (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>All individuals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before inclusion</td>
<td>1386</td>
<td>1261</td>
<td>252 (–71 to 581)</td>
</tr>
<tr>
<td>During follow-up</td>
<td>1849</td>
<td>1905</td>
<td>–22 (–318 to 236)</td>
</tr>
<tr>
<td>Individuals taking medications at baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before inclusion</td>
<td>2698</td>
<td>2628</td>
<td>180 (–496 to 747)</td>
</tr>
<tr>
<td>During follow-up</td>
<td>2730</td>
<td>3169</td>
<td>–295 (–807 to 149)</td>
</tr>
<tr>
<td>Individuals not taking medications at baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before inclusion</td>
<td>0</td>
<td>0</td>
<td>160 (–115 to 449)</td>
</tr>
<tr>
<td>During follow-up</td>
<td>865</td>
<td>715</td>
<td></td>
</tr>
</tbody>
</table>

*One person is excluded from the cost calculations owing to extreme costs for cancer medications. †SOS indicates Swedish obese subjects; CI, confidence interval; and SEK, Swedish kronor. ‡Adjusted for age, sex, body mass index and, in the case of follow-up, total cost at baseline (bootstrap CI).

Table 5. Average Yearly Cost During the Year Before Inclusion and for 6 Years of Follow-up for Each Medication Group in 509* Surgically and 455 Conventionally Treated Obese Individuals in the SOS Intervention Study†

<table>
<thead>
<tr>
<th>Medication Group</th>
<th>Diabetes Mellitus</th>
<th>CVD</th>
<th>NSAIDs/Pain</th>
<th>Asthma</th>
<th>PD</th>
<th>Anemia</th>
<th>GID</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Average Cost per Year, SEK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2 years</td>
<td>Surgical group</td>
<td>134</td>
<td>464</td>
<td>153</td>
<td>213</td>
<td>62</td>
<td>4</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Conventional group</td>
<td>54</td>
<td>453</td>
<td>110</td>
<td>127</td>
<td>71</td>
<td>2</td>
<td>212</td>
</tr>
<tr>
<td>Difference (95% CI)‡</td>
<td>(11 to 205)</td>
<td>(–61 to 193)</td>
<td>(–19 to 112)</td>
<td>(–17 to 243)</td>
<td>(–63 to 34)</td>
<td>(–2 to 7)</td>
<td>(–208 to 140)</td>
<td>(–145 to 68)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>Surgical group</td>
<td>44</td>
<td>429</td>
<td>248</td>
<td>164</td>
<td>144</td>
<td>66</td>
<td>312</td>
</tr>
<tr>
<td></td>
<td>Conventional group</td>
<td>140</td>
<td>622</td>
<td>175</td>
<td>165</td>
<td>133</td>
<td>13</td>
<td>198</td>
</tr>
<tr>
<td>Difference (95% CI)‡</td>
<td>(–125 to –61)</td>
<td>(–288 to –88)</td>
<td>(–9 to 142)</td>
<td>(–130 to 17)</td>
<td>(–39 to 105)</td>
<td>(35 to 67)</td>
<td>(27 to 244)</td>
<td>(–64 to 122)</td>
</tr>
</tbody>
</table>

*One person is excluded from the cost calculations owing to extreme costs for cancer medications. †SOS indicates Swedish obese subjects; CVD, cardiovascular disease; NSAIDs, nonsteroidal anti-inflammatory drugs; PD, psychiatric disorders; GID, gastrointestinal tract disorders; SEK, Swedish kronor; and CI, confidence interval. ‡Adjusted for age, sex, and body mass index and, during follow-up, drug-specific cost at baseline (bootstrap CI).

The cross-sectional part of this study shows that compared with a randomly selected sample from the general population, the total annual cost of prescribed medications is 77% higher in obese individuals (783 vs 1387 SEK per year and person). Use of diabetes mellitus medications was 9 times more common and use of CVD medications was 9 times more common in the obese population.

Although cross-sectional studies3,4 have reported total use of medications in lean and obese individuals and some studies7-9 have estimated the total cost of medications in the obese, only 3 additional studies3,6,30 to our knowledge, have measured total use and calculated the corresponding total cost of medications in lean and obese individuals. Compared with BMI in the reference range, a BMI greater than 30 or 35 was associated with a 55% to 78% increase in pharmaceutical costs. These values from the United States and France are thus in agreement with our Swedish findings. So far, to our knowledge, there is only one study30 available comparing costs for a couple specific medication groups in lean and obese individu-
als. In that retrospective cohort study, the total pharmaceutical cost was doubled in obese individuals, and the annual cost for 9 years was 13 times higher for diabetes mellitus medications and 3 times higher for cardiovascular medications compared with normal weight individuals. In our study, large and statistically significant cost increases in the obese population were seen for the drug groups CVD, diabetes mellitus, asthma, and NSAIDs/pain compared with corresponding costs in the general population.

Our cross-sectional data indicate the potential cost savings for specific groups of medication. However, the available medical and surgical treatments for obesity rarely eliminate all of the patient’s overweight and comorbidities. Therefore, it is not likely that the medication costs could be reduced to the same level as in the general population, even after substantial and sustained weight reductions. In fact, a recent study implies that a sustained weight reduction of at least 10% to 15% is needed to substantially reduce the use of medication for diabetes mellitus and CVD after 6 years.23

During 6 years of follow-up, the yearly inflation-adjusted total cost of medications increased continu-
from 1261 to 2633 SEK in the conventionally treated, weight-stable obese group. In the surgically treated group, with an average weight loss of 16% in 6 years, the development was similar (from 1386 to 2607 SEK), and the annual average cost during 6-year follow-up was not significantly different between the 2 groups. Cost reductions were seen for diabetes mellitus medications (69% lower cost than for conventional treatment) and CVD medications (31% lower cost than for conventional treatment) in the surgically treated patients, but these savings were balanced by higher costs for other groups of medication, particularly GID, NSAIDs/pain, and anemia.

The lack of effect of intentional weight loss on total cost of medications in our prospective, controlled intervention study for 6 years is difficult to compare with other studies because they are only reporting use or costs of some specific medication. However, long-term retrospective (9- and 6-year) and prospective (8-year) surgical studies with weight-stable obese control groups clearly indicate that the incidence of and recovery from diabetes and CVD medications were markedly improved by intentional weight loss. The study by MacDonald et al and two 1-year, randomized antiobesity drug trials in obese patients with type 2 diabetes mellitus reported reduced use of diabetes mellitus medications. Finally, 2 short-term (≤1 year) noncontrolled weight loss studies found reduced use and cost of diabetes mellitus medications. Our controlled 6-year data show that the use and cost of diabetes mellitus medications was reduced by intentional weight loss in patients taking and not taking diabetes mellitus medications at baseline.

Several studies, lacking a weight-stable control group or being short-term observations, have reported reduced use of medications for hypertension after weight loss. In addition, long-term (3- to 4-year) randomized intervention studies of patients with hypertension have shown that weight loss reduces the amount of medication needed to reach a target blood pressure. Furthermore, one small, uncontrolled, short-term study reported decreased medication costs after pharmaceutical treatment of obesity. Our controlled data show a reduction in all CVD medication costs after long-term sustained weight loss.

In a recent intervention trial of obese persons with asthma, weight reduction achieved by dietary means was associated with reduced symptoms of asthma and reduced use of oral corticosteroids, although the use of rescue medications was not changed in 1 year. Surgically induced weight loss has also been reported to have a beneficial effect on asthma and asthma medication use, but these studies were small and lacked control groups. In the present study, the surgically treated group tended to have lower costs for asthma medications during follow-up. However, this difference vs the conventionally treated group did not reach full significance, and the propor-

![Figure 3. Proportion of patients taking medications in the conventionally and surgically treated groups in the Swedish Obese Subjects intervention study for all prescribed drugs combined. Patients taking medication (262 surgically and 220 conventionally treated) had at least 1 prescribed drug at baseline. Patients not taking medication (248 surgically and 235 conventionally treated) did not have any prescribed drugs at baseline.](image1)

![Figure 4. Unadjusted average cost per year for 6 years of follow-up for each medication group in the Swedish Obese Subjects intervention study in persons taking (A) and not taking (B) the respective medications at baseline. The numbers in parentheses are the number of conventionally/surgically treated individuals in each group at baseline. Error bars represent 95% confidence intervals. Asterisk indicates a statistically significant difference at P=.05, adjusted for age, sex, body mass index, and the drug-specific medication cost at baseline. CVD indicates cardiovascular disease; NSAIDs, nonsteroidal anti-inflammatory drugs; PD, psychiatric disorders; GID, gastrointestinal tract disorder; and SEK, Swedish kronor. For other details on medication groups, see the “Methods” section.](image2)
tion of patients continuing their use of asthma medicating
did not differ between the 2 obese treatment groups in
our study.

The following limitations of our study have to be con-
considered. First, the baseline data for the SOS interven-
tion study population and the medication data for the gen-
eral population were collected during different periods.
The introduction and widespread use of new pharma-
ceuticals, for example, antidepressants and proton pump
inhibitors, and new guidelines for the treatment of dia-
betes mellitus during recent years has probably affected
the expenses more in the general population group, which
was studied later. Thus, the cost differences between the
obese and general populations could be even more pro-
nounced than indicated by our data. On the other hand,
data on medication use were available for only approxi-
mately 55% of the reference population, and the state of
health of nonrespondents is unknown. If more diseased
individuals were less likely to participate, the use of med-
cation might be underestimated in the general popula-
tion. Still, the comparison provides a comprehensive, al-
beit rough, estimate of various medical costs associated
with obesity, particularly because the reference group was
randomly selected. Second, the SOS intervention study
is based on a selected group of individuals. Participants
were self-selected and were recruited by advertisements
in public media. Furthermore, several exclusion criteria
were used. To be included in the SOS intervention study,
the patients had to be operable and also eligible accord-
ing to the study protocol. Therefore, obese individuals
with severe illnesses, abuse, and so on, were not al-
lowed to enter the study. Thus, our study population prob-
ably has a better health status than the general obese pop-
ulation. Third, information on the use of medications
was self-reported and was collected from dispatched
questionnaires, which could affect the reliability of the
data. Because we had no access to objective data on drug
consumption, we could not validate these questions.
However, information on medication use in the refer-
ce population was obtained by the same methods as
in the intervention study. Finally, we cannot preclude
the possibility that participation in the study per se could
affect medication use. Participation in the study, with
repeated health examinations, could theoretically in-
crease awareness of symptoms and the likelihood of
detection of various comorbidities.

In conclusion, medication use for diabetes mellitus
and CVD is markedly increased and medication use for
muscle inflammation, rheumatic disorders, and pain and
for asthma is moderately increased in obese individuals
compared with the general population. Thus, obese per-
sons have considerably higher medication costs than the
general population. The total pharmaceutical costs for 6
years are not reduced by an average weight reduction of
16%, achieved by surgical treatment of obesity. Surgi-
cally treated patients have lower pharmaceutical costs for
diabetes mellitus and cardiovascular disease, but this cost
reduction is counterbalanced by a postoperative in-
crease in medication costs for muscle inflammation, rheu-
matic disorders, and pain; gastrointestinal disorders; and
anemia and vitamin deficiency. It remains to be studied
whether large, maintained, intentional weight losses affect
the total cost of medications in 10 to 20 years or in the
remaining lifetime.

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Corresponding author and reprints: Kristina Narbro,
PhD, SOS secretariat, Department of Internal Medicine, Sahlg-
grenska University Hospital, SE-41345 Göteborg, Sweden
c(e-mail: kristina.narbro@medfak.gu.se).

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