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

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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.

Arch Intern Med. 2002;162:2061-2069

OBESITY IS associated with elevated morbidity and mortality rates.1 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.2 The high morbidity rate and the associated increased drug use3-6 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 obesity4 and that approximately 30% of these costs are pharmaceutical costs for treating obesity-related disorders 5-9.

Intentional weight loss in the obese population can reduce cardiovascular risk factors10-15 and the associated use of medication,16-21 although the long-term effects on hypertension have recently been questioned.22 Few studies16,17 have calculated the effect of weight loss on pharmaceutical costs for specific obesity-related diseases. Recently, we23 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.
SO3 STUDY

The SO3 project is an ongoing nationwide intervention trial of obesity that began in 1987.24 The primary aim is to determine whether mortality and morbidity rates in obese persons can be reduced by surgical treatment and weight reduction. The SO3 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 healthcare 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; 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 band gastroplasty according to the local practice at the surgical department concerned.25 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 SO3 reference study is a population study conducted in the county of Malmö in southern Sweden during 1994 to 1999.25 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 SO3 registry study. Follow-up examinations are planned after 10, 15, and 20 years.

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 SO3 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 SO3 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 SO3 intervention study. These 1294 patients, included between 1987 and 1992, are the same as were used in the comparison with the reference study previously mentioned. Only individuals with complete 6-year follow-up were included in this comparison (n=963). 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 SO3 projects are approved by 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 0.01 m. Information on prescribed medications, including dosage and strength, was collected from questionnaires filled out by all participants at inclusion in the SO3 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 SO3 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).
- Cardiopulmonary disease: ATC groups C01 (cardiac therapy), C02 (antiangertensives), C03 (diuretics), C07 (β-adrenergic blocking agents), C08 (calcium channel blockers), and C09 (agents acting on the renin-angiotensin system).
- Gastrointestinal tract disorders (GID): ATC groups A02 (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 Pharmacists. 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. We report unadjusted proportions and adjusted risk ratios (adjusted to the mean values of age, sex, and smoking). For surgically and conventionally treated groups in the SOS intervention study, changes in the proportions of obese persons taking medications at follow-up were compared similarly, and risk ratios were adjusted to the mean values of age, sex, and BMI at baseline. When comparing medication costs for the obese and reference populations and changes for the surgically and conventionally treated groups, we report mean values in each group. Owing to skewed distribution of the cost variables, statistical tests of equality between the groups were performed by constructing confidence intervals (CIs) based on bootstrap percentiles. 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 (227 SEK), GID (177 SEK), and asthma (155 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

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**Table 1. Baseline Characteristics of Obese Individuals in the SOS Intervention Study and the Randomly Selected Reference Population**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SOS Intervention Group</th>
<th>Reference Group</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals selected, total No.</td>
<td>1294</td>
<td>1752</td>
<td>. .</td>
</tr>
<tr>
<td>Individuals with information about medications, No.</td>
<td>1286</td>
<td>958</td>
<td>. .</td>
</tr>
<tr>
<td>Men, %</td>
<td>31.4</td>
<td>44.5</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Smokers, %</td>
<td>26.5</td>
<td>20.3</td>
<td>.001</td>
</tr>
<tr>
<td>Taking medication, %</td>
<td>52.0</td>
<td>35.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age at inclusion, mean (SD), y</td>
<td>47.7 (6.0)</td>
<td>49.5 (6.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BMI at inclusion, mean (SD), kg/m²</td>
<td>41.0 (6.6)</td>
<td>25.0 (3.7)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Cost of all medications in the year before inclusion, mean (SD), SEK</td>
<td>1387 (2546)</td>
<td>783 (2082)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*SOS indicates Swedish obese subjects; BMI, body mass index; and SEK, Swedish kronor.*
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>Taking medication, %</th>
<th>Cost, SEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes Mellitus</td>
<td>6.1</td>
<td>107</td>
</tr>
<tr>
<td>CVD</td>
<td>27.8</td>
<td>457</td>
</tr>
<tr>
<td>NSAIDs/Pain</td>
<td>10.8</td>
<td>148</td>
</tr>
<tr>
<td>Asthma</td>
<td>5.2</td>
<td>155</td>
</tr>
<tr>
<td>PD</td>
<td>7.2</td>
<td>99</td>
</tr>
<tr>
<td>Anemia</td>
<td>1.3</td>
<td>7</td>
</tr>
<tr>
<td>GID</td>
<td>4.4</td>
<td>177</td>
</tr>
<tr>
<td>Other</td>
<td>20.5</td>
<td>227</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medication Group</th>
<th>Risk ratio (95% CI)†</th>
<th>Difference (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes Mellitus</td>
<td>9.2 (4.2-20.0)</td>
<td>94 (51-141)</td>
</tr>
<tr>
<td>CVD</td>
<td>4.1 (3.3-5.1)</td>
<td>384 (311-454)</td>
</tr>
<tr>
<td>NSAIDs/Pain</td>
<td>2.9 (2.0-4.1)</td>
<td>100 (64-137)</td>
</tr>
<tr>
<td>Asthma</td>
<td>2.3 (1.4-3.8)</td>
<td>91 (17-164)</td>
</tr>
<tr>
<td>PD</td>
<td>1.4 (1.0-2.0)</td>
<td>-55 (-129 to 7)</td>
</tr>
<tr>
<td>Anemia</td>
<td>0.8 (0.4-1.5)</td>
<td>1 (-5 to 6)</td>
</tr>
<tr>
<td>GID</td>
<td>1.3 (0.8-1.9)</td>
<td>34 (-59 to 136)</td>
</tr>
<tr>
<td>Other</td>
<td>0.8 (0.7-1.0)</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>455</td>
<td>1294</td>
</tr>
<tr>
<td>Individuals with complete 6-y follow-up, No.</td>
<td>510</td>
<td>482</td>
<td>995</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 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. 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 2048 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**

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 significant but 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, −295 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, 36-278 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.
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.

Although cross-sectional studies\(^5,6,\) have reported total use of medications in lean and obese individuals and some studies\(^7-9\) have estimated the total cost of medications in the obese, only 3 additional studies,\(^5,6,30\) 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 study\(^6\) available comparing costs for a couple specific medication groups in lean and obese individuals. 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.

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 77% higher in obese individuals (783 vs 1387 SEK per year and person).

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 77% higher in obese individuals (783 vs 1387 SEK per year and person). Use of diabetes mellitus and CVD after 6 years.

*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).
loss. The study by MacDonald et al21 and two 1-year, ran-
tutes mellitus are markedly improved by intentional weight
indicate that the incidence of and recovery from diabe-
studies with weight-stable obese control groups clearly
noncontrolled weight loss studies16,17 found reduced use
of medications for hypertension
In a recent intervention trial16 of obese persons with
Asthma, weight reduction achieved by dietary means was
assembled to have lower costs for asthma medications during follow-
upper 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 pa-
tients, but these savings were balanced by higher costs
for other groups of medication, particularly GID,
 NSAIDs/pain, and anemia.

Figure 3. Proportion of patients taking medications in the conventionally
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. Asterisk indicates a
statistically significant difference at P=.05, adjusted for age, sex, and body
mass index at baseline.

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.

The lack of effect of intentional weight loss on total
cost of medications in our prospective, controlled inter-
vention 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 retrospec-
tive21 (9- and 6-year) and prospective22 (8-year) surgical
studies with weight-stable obese control groups clearly
indicate that the incidence of and recovery from dia-
tes mellitus are markedly improved by intentional weight
loss. The study by MacDonald et al21 and two 1-year, ran-
domized antiobesity drug trials30,31 in obese patients with
type 2 diabetes mellitus reported reduced use of dia-
tes mellitus medications. Finally, 2 short-term (≤1 year)
noncontrolled weight loss studies16,17 found reduced use
and cost of diabetes mellitus medications. Our con-
trolled 6-year data show that the use and cost of dia-
tes 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
group32,33 or being short-term observations,15,19,34 have
reported reduced use of medications for hypertension
after weight loss. In addition, long-term (3- to 4-year)
randomized intervention studies20,35 of patients with
hypertension have shown that weight loss reduces the
amount of medication needed to reach a target blood pres-
ure. Furthermore, one small, uncontrolled, short-term
study17 reported decreased medication costs after phar-
maceutical treatment of obesity. Our controlled data show
a reduction in all CVD medication costs after long-term
sustained weight loss.

In a recent intervention trial16 of obese persons with
asthma, weight reduction achieved by dietary means was
associated with reduced symptoms of asthma and re-
duced use of oral corticosteroids, although the use of re-
sue medications was not changed in 1 year. Surgically
induced weight loss has also been reported to have a ben-
eficial effect on asthma and asthma medication use,37,38
but these 2 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-
tion of patients continuing their use of asthma medications did not differ between the 2 obese treatment groups in our study.

The following limitations of our study have to be considered. First, the baseline data for the SOS intervention study population and the medication data for the general population were collected during different periods. The introduction and widespread use of new pharmaceuticals, for example, antidepressants and proton pump inhibitors, and new guidelines for the treatment of diabetes 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 pronounced than indicated by our data. On the other hand, data on medication use were available for only approximately 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 medication might be underestimated in the general population. Still, the comparison provides a comprehensive, albeit 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 according to the study protocol. Therefore, obese individuals with severe illnesses, abuse, and so on, were not allowed to enter the study. Thus, our study population probably has a better health status than the general obese population. 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 reference 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 increase 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 persons 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. Surgically treated patients have lower pharmaceutical costs for diabetes mellitus and cardiovascular disease, but this cost reduction is counterbalanced by a postoperative increase in medication costs for muscle inflammation, rheumatic 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.

Accepted for publication February 27, 2002. This study was supported by grant 05239 from The Swedish Medical Research Council, Stockholm, Sweden; Hoffmann-La Roche Ltd, Basel, Switzerland; the Volvo Research Foundation, Göteborg; Centre for Public Sector Research, Göteborg; The Swedish Social Welfare Board, Stockholm; the Ministry of Education, Stockholm; Scandia Insurance, Stockholm; and the Research Committee of Örebro County Council, Örebro, Sweden.

This study was presented as a poster at the 11th European Congress on Obesity, Vienna, Austria, May 31, 2001.

We are grateful to members of the steering, laboratory, and safety monitoring committees of the Swedish Obese Subjects Intervention Study and to the staff at the 25 surgical clinics and 480 primary health care centers in Sweden for their help and cooperation.

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