REVIEW

Bariatric Surgery

Results from the Scandinavian Obesity Surgery Registry: A narrative review

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Summary
In 2007, the Scandinavian Obesity Surgery Registry (SOReg) was started by the profession to monitor the results of bariatric surgery and to provide a high-quality database for research. In the end of August 2023, SOReg contains 88,379 patients (body mass index [BMI] 41.7 kg/m², 41.2 years, 77.1% females, gastric bypass 76.8%). In this narrative review, we demonstrate that preoperative weight loss is of value and that the laparoscopic double omega-loop technique is highly suitable for gastric bypass. Closing the mesenteric openings is, however, important. Swedish bariatric surgery has low mortality, and our results are comparative to those of other countries. Significant long-term improvements are found in common obesity-related diseases such as diabetes, hypertension, and sleep apnea. Furthermore, the risk for cardiac failure and major adverse cardiovascular events is significantly reduced. Pregnancy-related outcomes are also improved. Gastric bypass results in significant improvements in quality of life and seems to be cost saving. We have revealed that low socioeconomic status is associated with reduced chance of undergoing bariatric surgery and inferior outcomes. Of note, we have performed several randomized clinical trials within the registry database. In conclusion, high-quality national registry databases, such as SOReg, are important for maintaining high-quality care and present a platform for extensive research.

KEYWORDS
bariatric surgery, gastric bypass, long-term results, quality of life, quality registry, socioeconomic

INTRODUCTION

Sweden has a long history of bariatric surgery, and in 2007, the Scandinavian Obesity Surgery Registry (SOReg) was started by the profession. The aim of this national quality registry was to monitor the results of metabolic and bariatric surgery (henceforth called bariatric surgery) and to provide a high-quality database for research. When more than 100 scientific papers (n = 144), utilizing data from SOReg, have been published in peer-reviewed journals, we found it valuable to summarize our findings in a narrative review.

In the end of August 2023, SOReg contains 88,379 patients (body mass index [BMI] 41.7 kg/m², 41.2 years, 77.1% females). Gastric bypass dominates (n = 67,876, 76.8%) followed by sleeve gastrectomy (n = 19,097, 21.6%), while biliopancreatic diversion with duodenal switch, gastric banding, and various revisional procedures make up the rest. Therefore, studies on gastric bypass dominate our research so far.

After describing the registry, this narrative review will be divided into the following five main parts: patient selection, surgical procedures and perioperative regime, long-term complications, effect on obesity-related diseases and other conditions, and improvements in

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quality of life. Our results are compared to the literature, and their effect on clinical care in Sweden will be presented. We also present data from some specific areas such as health economy and various prediction models.

1.1 | Content and data quality in SOReg

The SOReg database is divided into three separate parts: baseline data, perioperative results, and long-term follow-up at 1, 2, 5, 10, and 15 years. The register contains 294 primary variables, of which 154 are mandatory. In addition, there are 41 automatically calculated variables, such as BMI and excess BMI loss, and 353 secondary and tertiary variables. The SOReg database holds administrative data, patient demographics, medical conditions such as obesity-related diseases, and operative data, including short- and long-term complications, as well as laboratory data and patient-reported outcome measures, including general and obesity-specific quality of life. The latter are measured by the 36-Item Short Form Health Survey, developed by RAND (RAND-36) and the Obesity-Related Problems Scale. All data entry is done online, and since 2013, all bariatric centers, both public and private, participate in SOReg. Recently, the acquisition rate, internal validity, and completeness in SOReg were found high, 97.4%, 99.0%, and 100%, respectively.

1.2 | Acquired knowledge in published papers based on SOReg data

Among the 144 published papers in December 2022, based on SOReg data, we have selected 83, which will be presented in a patient perspective, that is, starting from the preoperative phase, and not in publication order.

2 | PATIENT SELECTION

In Sweden, it is estimated that around 175,000 adult individuals are potential candidates for bariatric surgery (BMI ≥ 35, age 18–60 years), but with an annual operative volume of about 50/100,000, less than 3% of the affected individuals are offered this treatment option. To investigate the selecting mechanisms for bariatric surgery, we used the National Diabetes Registry to match 5321 gastric bypass-operated patients 1:1 with non-operated controls. Despite similar clinical data, greater socioeconomic status was associated with a higher rate of bariatric surgery. Similar referral patterns have been identified in cancer surgery and warrant action, especially in a publicly financed healthcare system.

3 | SURGICAL PROCEDURE AND PERIOPERATIVE REGIME

When starting the registry, we observed five aortic injuries (0.043%) in 11,744 laparoscopic gastric bypass procedures, all occurring when placing an optical trocar before establishing pneumoperitoneum. Outcomes varied from no major sequela to bilateral lower limb amputation and death. After drawing the attention of Swedish surgeons to this problem, direct placement of an optical trocar decreased (45% to 30%), and only 12 minor intraabdominal injuries, evenly distributed between the two techniques, were found in a follow-up survey.

In 2007, various operative techniques were used in gastric bypass: open or laparoscopic approach, circular or linear stapling of the gastrojejunostomy, and antecolic or retrocolic passage of the Roux limb. After demonstrating a doubled risk of strictures (odds ratio [OR] 2.7) in a retrospective study, the circular stapled gastrojejunostomy was abandoned. However, in the prevailing double omega-loop technique, suturing of the remaining opening in the two linear stapled anastomoses can be technically demanding. In a retrospective cohort study of 25,006 primary laparoscopic gastric bypass, we noted that the total operative time was 11 min (16%) shorter when using a unidirectional barbed suture compared to conventional polyfilament. This, in combination with the lack of increased complication risk, resulted in a substantial increase in the routine use of barbed sutures among Swedish surgeons. In a similar sized retrospective study, a closed staple height of <1.5 mm was associated with 30% lower risk for postoperative complications, including bleeding and leakage.

When constructing the gastric pouch, most centers start by a horizontal 45-mm cartridge and reach the angle of His after using one 90-mm and one 45-mm stapler, that is, a total stapling length of 145 mm. Using stapling length as proxy for pouch size in a retrospective study, a 14% increased risk of marginal ulcers was found for each extra centimeter of stapling. Furthermore, inferior weight loss, often prevalent in patients with larger pouches, was associated with an increased risk of marginal ulcers. As the use of prophylactic proton pump inhibitors did not reduce the rate of acid-related complications in a retrospective cohort study, Swedish surgeons have a clear objective to create small pouches, using linear cartridges with low staple height.

3.1 | Early postoperative complications

In 2010–2012, the overall risk of serious postoperative complications (Clavien–Dindo ≥3b) was 3.4%. The majority (n = 598, 3.2%) had intervention under general anesthesia, while 24 had single or multiorgan dysfunction and died. During primary laparoscopic gastric bypass, intraoperative adverse events (OR 2.63) and conversion to open surgery (OR 4.12) were the strongest risk factors for serious complications, followed by annual operative volume and total institutional experience. The indication that bariatric surgery should be kept focused was later confirmed by two other cohort studies, one demonstrating superior results at departments in general hospitals having higher proportions of bariatric procedures and another failing to find any weekday effect after adjustment for case-mix and operating center. Summer closure (performing no procedures during a...
period of at least 4 weeks) was, however, associated with a 17% increased risk for serious complications (4.0% vs. 3.4%) compared to the remaining part of the year.17

When retrospectively evaluating specific complications, anastomotic leakage, occurring at the gastrojejunosotomy or in the small bowel at around 0.5% in gastric bypass, was more common in men (OR 1.5), in older patients (≥49 years; OR 1.9), and in converted (OR 3.9) or prolonged surgery (operative time ≥90 min; OR 2.6). Of note, surgical reinsertion to drain the abdominal cavity was required in 97% of leakages, and a third of the patients required intensive care.18,19 Furthermore, intraoperative bleeding was associated with an increased risk for postoperative complications (OR 2.97 and OR 3.34, for 50–500 and >500 mL, respectively), whereas intentional preoperative weight loss was associated with a lower risk (OR 0.50).20 In 22,327 patients undergoing gastric bypass, initial median weight was reduced from 120 to 115 kg (4.8% total weight loss). When comparing patients in the 75th percentile (9.5% total weight loss) with those in the 25th percentile of preoperative weight loss, the overall risk of complications was reduced by 13%. For specific complications, the risk for anastomotic leakage was reduced by 24%, deep infection and abscess by 37%, and minor wound complications by 54%.21 Thus, the 5% total weight loss, considered acceptable by many surgeons, is probably insufficient. In addition, higher preoperative weight loss was also associated with improved weight result at 2 years after surgery.22 The findings resulted in a national guideline supporting preoperative weight loss by low-calorie diet, especially in patients with higher BMIs.

It is well known that patients with diabetes have an increased risk for postoperative complications. Interestingly, when retrospectively evaluating 12,850 patients without ongoing treatment for diabetes, an elevated HbA1c level (≥5.7%) was associated with an increased risk for severe complications.23 Thus, checking HbA1c levels is of interest in all patients, not only those diagnosed with diabetes. Also, several socioeconomic factors such as being divorced, widow, or widower and receiving disability pension or social assistance were associated with an increased risk for severe postoperative complications.24 The impact should not exclude patients from surgery but must be considered in preoperative risk assessment.

Start of early feeding has been an ongoing debate, but after adjusting for the annual volume of procedures, no increased risk for complications was retrospectively seen in the 9% of patients (n = 2074) returning to solid food within the first week after surgery.25 There is no benefit of beta-blockade on postoperative outcome after laparoscopic gastric bypass surgery26; however, continuous use of opioids or proton pump inhibitors preoperatively was associated with an increased risk of adverse outcome. Chronic opioid use, defined as ≥2 prescription of opioids within 90 days prior to surgery, was in a large cohort study associated with a higher risk of severe complications (OR 1.67), as well as increased length of stay and higher rates of readmission and reoperation.27 In contrast, a small dose of morphine (20 mg), given as a slow-release tablet on the morning of surgery, was associated with reduced need of analgesics and shorter hospital stay.28 For patients using proton pump inhibitors continuously, the risk for postoperative complications was increased (OR 1.24) in gastric bypass and doubled in gastric sleeve.29

At 2 years postoperatively, the 1403 patients who had an early serious complication reported higher intake of antidepressants, proton pump inhibitors, and opioids (7.3 vs. 17.0 mg/day), as well as increased need of hospital care (3.8 vs. 0.9 days during the first year after initial discharge).30 This observation has started a discussion on how to give affected patients specialized attention during initial follow-up. In three registry-based cohort studies including some 30,000 operated patients, an increased in consumption of opioid analgesics after gastric bypass and sleeve gastrectomy was found. The increase was most prominent in non-consumers31 and in patients with a low consumption prior to surgery,32 thus surpassing the use in patients with obesity having lifestyle intervention and the general population (53% vs. 38%).31 This awareness should lead to regular reassessments of pain mechanisms, hence preventing unnecessary opioid use in also this patient group.

### 3.2 | Mortality

In a recent cohort study, a very low overall 90-day and 1-year mortality rate was shown, 0.06% and 0.19%, respectively, both decreasing over the 10-year study period.33 The result is in line or below the data published from other countries.34–37 In a multivariate analysis, depression (OR 2.38), leakage (OR 9.32), and thromboembolic events (OR 7.60) increased mortality risks at both time points, whereas age and abdominal circumference were also associated with increased mortality at 1 year. The predictive value of the Obesity Surgery Mortality Risk Score (OS-MRS), constructed by DeMaria et al. in 2007,38,39 was also confirmed.

In summary, an optimized operative procedure and postoperative regime, can reduce the 30-day complication rate markedly. The low 90-day and 1-year mortality demonstrates that bariatric surgery in Sweden is safe (Figure 1).

### 4 | LONG-TERM COMPLICATIONS

Internal herniation resulting in bowel obstruction is a potentially serious complication with a reported incidence of at least 10%, increasing during pregnancy.40 Early reports suggested that closure of the mesenteric defects could reduce the risk, but long-term effects and risks were uncertain. In 2507 randomized patients, a marked reduction of small bowel obstruction was reported at 3 years when the mesenteric defects were closed, although to a cost of a small, but clinically relevant increase in the risk for early small bowel obstruction due to kinking of the jejunojejunostomy.41 At 10-year follow-up, the incidence of small bowel obstruction was reduced from 14.9% to 7.8% with mesenteric defects closure using running, non-absorbable sutures.42 These results were confirmed by a more recent randomized trial from Denmark evaluating a different technique for mesenteric defects closure.
The different techniques were further evaluated in an observational cohort study showing acceptable results with both methods, although the sutured technique was associated with slightly lower incidence of small bowel obstruction. The results of the original randomized study have also been validated in a national cohort operated during the same time period. Since 2016, all Swedish centers routinely close the mesenteric defects, resulting in a marked decrease in internal herniation (Figure 2).

**FIGURE 1** (A) Overall and (B) specific 30-day complication rates. Note the marked decrease in all complications and readmissions since the introduction of the Scandinavian Obesity Surgery Registry (SOReg) in 2007.

**FIGURE 2** The risk for internal herniation after gastric bypass, divided on four time points (31 days to 1 year, 1–2 years, 2–5 years, and 5–10 years) andoperative year. Note the marked decrease in internal herniation when closure of the mesenteric openings was commended in 2010.
4.1 | Deficiencies

There is a significant risk of developing deficiencies after bariatric surgery, with anemia, iron deficiency, and hypovitaminosis D being the most common. At 10 years postoperatively, 14% and 26% of our gastric bypass-operated women and men were found to have anemia (defined as hemoglobin below 117 and 134 g/L, respectively). Defining hypovitaminosis D as levels below 50 nmol/L, 24% of our gastric bypass patients were classified as deficient, both 5 and 10 years postoperatively. To improve this unacceptable situation, we have adopted Nordic guidelines for mineral/vitamin supplementation and follow-up after bariatric surgery, together with Norway, Denmark, and Finland. All individuals having had gastric bypass or sleeve gastrectomy are recommended a minimum daily dietary supplement of iron (45–60 mg), vitamin B12 (cyanocobalamin 350 μg), vitamin D (800 IE), always in combination with calcium (>500 mg, preferably in citrate form), folate (400 μg), thiamine (women 1.1 mg and men 1.4 mg), and zinc (9 mg).

4.2 | Socioeconomic aspects

The Swedish healthcare system differs from some parts of the world in that it is mainly funded by public means, and thus, bariatric surgery should be equally available despite socioeconomic status. However, when retrospectively evaluating patients with type 2 diabetes, higher socioeconomic status was associated with increased rate of bariatric surgery. In nationwide cohorts of patients with age-, sex-, and area of residence-matched controls, lower socioeconomic status increased the risk for early postoperative complications and reduced improvements in health-related quality of life after bariatric surgery. Despite a connection between postoperative weight loss and improvement of health-related quality of life, associations to postoperative weight loss appear to be weak for most socioeconomic factors. In the several cohort studies based on SOReg data, only immigration status (less improvement for first-generation immigrants) and living in larger cities were factors associated with reduced postoperative weight loss and lower chance of diabetes remission. These findings are supported by a recent meta-analysis reporting ethnicity as the only socioeconomic factor associated with differences in weight outcomes. While it is important to clarify that all socioeconomic groups have acceptable outcomes in terms of safety and efficacy after bariatric surgery, further studies and interventions may be necessary to ensure a more equal care delivered to all patients seeking treatment for obesity.

5 | EFFECT ON OBESITY-RELATED DISEASES AND OTHER CONDITIONS

Severe obesity is associated with several co-morbid diseases such as type 2 diabetes, cardiovascular disease, and renal disease, to mention a few. In a comprehensive cohort study of the outcome of gastric bypass on co-morbid disease, the effect on diabetes, hypertension, dyslipidemia, and sleep apnea was studied with a follow-up of 5 years. Significant improvements were found in all studied disease states, and by linkage to the prescribed drug registry, a near 100% follow-up was obtained. Massive and persistent weight loss is the cornerstone of improving obesity-related diseases. When comparing gastric bypass and sleeve gastrectomy in a Northwestern European cohort of 47,101 primary operations (70.1% gastric bypass), gastric bypass resulted in a higher rate of patients with total weight loss of more than 20% (95.8% vs. 84.6%, p < 0.001). Interestingly, while the weight loss after gastric bypass was similar between hospitals, there was a great variation in weight loss after sleeve gastrectomy. In the long term, SOReg data demonstrate a 25% total weight loss at 15 years for gastric bypass, while sleeve gastrectomy reaches 21% total weight loss at 5 years (28% for gastric bypass at that time point).

5.1 | Diabetes mellitus

The impact of diabetes has been studied in at least 20 registry-based publications. Besides being associated with remission of diabetes, fewer patients develop diabetes after surgery. Using data from the Swedish National Diabetes Registry, a decreased mortality in operated patients at 3.5 years was found, 1.8% versus 5.8% in the non-operated group. A follow-up study demonstrated that there was also an improvement in risk factors associated with cardiovascular disease and that weight loss was the main driving factor for both this and the reduced mortality. An additional study on the same patients demonstrated that renal function in patients with diabetes is significantly improved after surgery, which also may contribute to the above-mentioned reduced mortality in patients with diabetes that undergo surgery. It is well known that the duration of diabetes impacts the chance of remission. A retrospective cohort study utilizing SOReg data was able to demonstrate that this association is linear without any cutoffs, again emphasizing that bariatric surgery should not be delayed in patients with diabetes. In an expanded study, longer duration of diabetes, higher patient age, and higher HbA1c decreased the chance of remission of diabetes, while increased weight loss increased the chance of remission. Bariatric surgery in patients with type 1 diabetes has been somewhat controversial. We have demonstrated that patients with type 1 diabetes have similar benefits (reduced mortality and lower risk for cardiovascular disease and stroke) after surgery as patients with type 2 diabetes, but at a greater risk of hypoglycemia.

5.2 | Cardiovascular disease

The outcome of bariatric surgery has been extensively studied using prospectively collected SOReg data. The risk for cardiac failure is reduced by 50% in patients who underwent bariatric surgery compared to patients who underwent intensive lifestyle treatment. Patients with severe obesity and hypertension who underwent surgery were matched to patients with hypertension who did not
undergo surgery. Patients who underwent surgery had a significantly reduced risk [hazard ratio (HR) 0.73] for major adverse cardiovascular events (MACEs). Similar to remission of diabetes, high weight loss and male sex were associated with higher chance of remission of hypertension, while duration, number of antihypertensive drugs, age, BMI, cardiovascular disease, and dyslipidemia were associated with lower chance of remission of hypertension after surgery. The risk of MACEs was lower in those patients who were in remission of their hypertension at 2 years than those who were not. By cross-linkage of SOReg and the Swedish Web-System for Enhancement and Development of Evidence-Based Care in Heart Disease Evaluated According to Recommended Therapies registry (SWEDEHEART), matched patients with severe obesity and previous myocardial infarction were identified and compared to patients with a previous myocardial infarction who did not undergo surgery. Patients who underwent surgery had a significantly reduced risk for death, a new myocardial infarction, and cardiac failure demonstrating that bariatric surgery has secondary preventive effect on cardiovascular disease. Surgery was associated with a reduced risk for MACEs and mortality in patients with pre-existing heart disease and diabetes, as well as in patients with heart disease without diabetes. Patients with heart disease and diabetes seem to experience the highest risk reduction. Notably, the risk of postoperative complications is similar for patients with and without cardiovascular disease, with the exception for an increased risk of cardiovascular complications.

5.3 Effect on other conditions

Gallstone disease is associated with obesity and rapid weight loss. It is therefore not surprising that the risk for gallstone disease is increased after bariatric surgery. More importantly, we could retrospectively see that the risk of complications is lower if surgery for gallstones is performed before rather than after bariatric surgery. In pregnant women, however, the risk of complications after gallstone surgery did not differ between patients having had bariatric surgery or not. Obesity is associated with arthrosis in the knee joints. Bariatric surgery does however not seem to convey decreased risk for reconstruction after total knee replacement surgery for the first 2 years, although providing identical outcome in pain relief, activities of daily living function, and satisfaction. Unfortunately, gastric bypass surgery seems to be associated with an increased risk for fractures and an overall risk for fall injuries without fractures. In these cohort studies, there was no clear association between the risk for fractures and the degree of substitution and vitamin D and calcium after surgery.

After matching individuals with diabetes who had undergone gastric bypass with those not surgically treated for obesity, we could verify several side effects, such as abdominal pain and malnutrition, including a 92% higher risk for anemia, and that alcohol abuse was three times as great as in the control group. When using phospha-diethylanol (PEth) as a screening tool, the prevalence of alcohol over-consumption 2 years after gastric bypass was 8.3%, compared to 3.5% preoperatively. The transition from abusing food to alcohol and other substances is difficult to study but needs to be further examined. So is the increased number of suicides and non-fatal self-harm events (adjusted HR 3.16), when comparing gastric bypass to a matched intensive lifestyle group for 149,582 person-years.

Obesity is a common reason for infertility. It is also an important risk factor for morbidity and complications in mother and child. The knowledge about the impact of weight loss and bariatric surgery in this field is limited as it is not possible to perform randomized intervention studies for ethical reasons. Nor is the chance for women with obesity to become pregnant fully studied, but it is well known that obesity increases the risk for infertility and that this is reversed after bariatric surgery. More than 1000 babies are born each year in Sweden of mothers who have had surgical treatment for their obesity corresponding to 1%-2% of all newborns. In vitro fertilization (IVF) has a low chance to succeed in women with obesity and is often even not available for women with BMI above 30 kg/m². Bariatric bypass-operated women have the same cumulative live birth rate as non-operated of the same BMI. In a New England Journal of Medicine (NEJM) paper, a lower risk for gestational diabetes (1.9% vs. 6.8%) in mothers operated with gastric bypass compared to a similar control group matched with their preoperative BMI, age, parity, smoking, and year of delivery, as well as a decreased risk for large-for-gestational-age infants (8.6% vs. 22.4%), was shown, but an increased risk for small-for-gestational-age infants (15.6% vs. 7.6%). In an extended cohort, moderate pre-term birth (Weeks 32–37) was somewhat higher but not for very early pre-term birth (<Week 32). In a third study with similar design, a matched control group of post-surgery women was less likely to have cesarean delivery (18.2% vs. 25.9%), especially for emergency cesarean. They also had lower risk of instrumental delivery, induction of labor, post-term pregnancy, obstetric anal sphincter injury, and postpartum hemorrhage (4.6% vs. 8.0%). Furthermore, the risk for pre-eclampsia was strongly decreased, especially in nulliparous women. Obesity and poor blood sugar control in the mother are associated with offspring birth defects, a risk that decreases after gastric bypass.

One disease not traditionally associated with obesity is multiple sclerosis. However, weight loss may convey significant benefits in terms of mobility. Data from SOReg and the Swedish multiple sclerosis registry have demonstrated that bariatric surgery is safe in patients with multiple sclerosis and results in improvements in health-related quality of life. However, the time to 6-month confirmed disability progression during the first 5 years after baseline was shorter among the surgical patients (HR 2.31). No differences were observed regarding postoperative annual relapse rate or time to first postoperative relapse. Thus, although bariatric surgery appears to be a safe and efficient treatment of obesity in patients with multiple sclerosis, the clinical course of the disease might be slightly negatively affected.

6 IMPROVEMENTS IN QUALITY OF LIFE

SOReg contains one of the largest databases in the world for quality of life before and after bariatric surgery. Health-related quality of life...
is measured by using the 36-Item Short Form Health Survey, developed by RAND, and the specific Obesity-Related Problems Scale. Measurements are available at baseline (n = 57,000) and during follow-up (n = 43,000 and 3500 at 1 and 10 years, respectively). Several cohort studies have shown significant improvements in all modalities of RAND-36 and the Obesity-Related Problems Scale during the first 2 years after surgery, more so within the Obesity-Related Problems Scale and the physical components of RAND-36. At 5 years, no change can be seen for the mental health components of RAND-36, whereas the other components are still significantly improved. The most important factors for improved health-related quality of life besides weight decrease were postoperative complication and preoperative medication for depression. No big differences were seen between sexes, but younger patients had better improvements in physical components of RAND-36. The improvements for physical domains of RAND-36 and the Obesity-Related Problems Scale were less pronounced in young adults (18–25 years), despite a better weight result compared to the remaining patients. Changes in mental domains of SF-36 were negligible for both groups at 5 years after surgery.

Associations of bariatric surgery with changes in interpersonal relationship status were studied with data from SOReg combined with data from the Swedish Obese Subjects (SOS) study and with controls from the general population. An increased incidence of divorce and separation was seen after bariatric surgery but also an increase in incidence of new relationships for patients that where singles at time of surgery.

Health-related quality-of-life data from SOReg have provided more realistic preoperative information in so much that significant improvements in physical and social health can be expected, but not in mental health. The data have also resulted in recommendations of closer follow-up regarding mental health.

7 | OTHER SPECIFIC AREAS SUCH AS HEALTH ECONOMY AND PREDICTION MODELS

In an advanced economic decision analytic model using the Markov process, covering cardiovascular diseases, type 2 diabetes, and surgical complications, bariatric surgery was cost saving in comparison with conservative management. Over a lifetime, surgery led to savings of €8408 and generated an additional 0.8 years of life, corresponding to 4.1 quality-adjusted life years (QALYs) per patient. This translates into savings of €66 million for the studied cohort, patients operated in 2012. The lifetime results of savings, additional years of life, and QALYs are very similar to other European countries, €8522 to €9332, 0.5 to 1.1 years, and 3.2 to 5.0 QALYs, respectively, in Belgium. Germany and Italy. In another cohort study, we found that the 3.5-fold higher preoperative absenteeism in patients having gastric bypass surgery, compared to a sex-, age-, and income-matched reference population, remained postoperatively.

As established risk prediction models, based on factors associated with an increased risk for serious postoperative complications such as revision surgery, high age, low BMI, and large waist circumference, had too low sensitivity to predict risk in the individual patient case, artificial intelligence was added. However, not even this was safe enough to predict the risk of postoperative complications or effect on quality of life in clinical practice. Adding machine learning (convolutional neural network), the prediction of cessation of antidiabetic drugs and complete remission of type 2 diabetes after gastric bypass surgery was 9%–12% better than traditional predictive indices.

8 | STRENGTHS AND LIMITATIONS OF THE INCLUDED STUDIES

The use of a unique and identical personal identification number in SOReg and all other administrative national databases and quality registries is invaluable as it allows cross-linking of data. When evaluating the individual studies, this and the completeness of information in SOReg itself are major strengths. Although a substantial number of the included studies are randomized clinical trials (RCTs), many are retrospective or include a learning curve effect. Technology development and better training of surgeons and anesthesiologists, as well as improved patient selection and changes over time in hospital care, are also limitations.

8.1 | Success factors of the SOReg registry

The well-balanced set-up of the SOReg, including a carefully selected number of well-defined variables, and the possibility of easy online registrations for users have been most important in achieving high acquisition rate and completeness. Furthermore, when opening SOReg, the user receives an updated and center-specific status on five quality indicators: length of stay, readmittance within 30 days, rate of severe complications within 30 days, and follow-up rate at 1 and 2 years. Thus, users note that their contribution is recognized, while improving overall care.

Concerning scientific projects, posting an application form for obtaining registry data online simplifies the process for researchers, while the subsequent scrutinizing of all potential projects in the SOReg steering committee has reduced the risk of competing projects and double publication. Clinical registries, like SOReg, with high coverage and high quality of data can also be used for recruitment, randomization, and follow-up of patients in RCTs. After including a randomization module in the registry, we were able to run the above-mentioned studies on closure of the mesenteric defects and internal herniation as full registry-based RCTs (R-RCTs). This added feature truly facilitated both the inclusion and collection of data within this national study. At present, we are completing another R-RCT, the Bypass Equipoise Sleeve Trial (BEST), comparing the two most frequent procedures, laparoscopic gastric bypass and sleeve gastrectomy.
8.2 | Dissemination of results

The register offers three annual written reports concerning the following: (1) surgical statistics and early complications; (2) follow-up, changes in weight and comorbidity, and long-term complications; and (3) quality of life, revisional surgery, and research. We also have annual user meetings, presenting local and national results, together with short presentations on recent scientific work and its clinical implications. This direct contact with the users, both specialized nurses and bariatric surgeons, has been very valuable in disseminating our results and hence improving patient care. It is also an invaluable opportunity to communicate administrative improvements and other changes in the registry.

8.3 | Future aspects

The use of an identical copy of the Swedish SOReg database in Norway (SOReg-N) has expanded our possibility to perform joint research studies. The Swedish SOReg data and our quality indicators will be used by the National Board of Health and Welfare when evaluating their newly introduced National Guidelines for Obesity Care in Sweden. We believe that the latter will increase the general awareness of obesity as a chronic condition and thus improve referral rates to bariatric surgery and subsequent long-term follow-up of operated patients. The number of patients with long-term follow-up data needs to be improved. One mechanism for this can be automatic transfer of data from patient charts to SOReg.

At present, 14 individual PhD projects are currently based on SOReg data, and when these are finished, the register has been involved in 31 dissertations (Table S1).

8.4 | Comparison to other bariatric registries

In comparison to other bariatric registries, the proportion of gastric bypass procedures is high in SOReg (76.1%). The International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) Global Registry, containing 480,970 bariatric surgeries from 24 countries, includes only 28.8% gastric bypass procedures, while sleeve gastrectomy dominates (63.9%). Otherwise, the median preoperative BMI (40–45 kg/m²), patient age (34–45 years), and gender distribution (79% females) are like that reported in SOReg, 41.7 kg/m², 41.2 years, and 77.1%, respectively. As earlier stated, the operative mortality in SOReg is in line with results from other countries. So is also the unplanned return to theater, intensive care unit (ICU) care, and readmission to hospital. Like SOReg, the American Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) containing 690,770 observations (mean BMI 45.2 kg/m², age 44.5 years) reports a continuous improvement in several outcomes, especially perioperative complications and readmissions.

9 | CONCLUSION

The creation of the SOReg in 2007 has been a success based on the high participation rate and high-quality data. In this narrative review, we have demonstrated that preoperative weight loss is of value before bariatric surgery and that the laparoscopic double omega-loop technique is suitable for gastric bypass as it results in a low complication risk. However, the incidence of small bowel obstruction has been halved, from 14.9% to 7.8%.

Significant improvements were found in common obesity-related diseases such as diabetes, hypertension, dyslipidemia, and sleep apnea. Concerning cardiovascular disease, the risk for cardiac failure and MACEs was significantly reduced after bariatric surgery. Interestingly, this was also true for patients with previous myocardial infarction or other pre-existing heart diseases, whom could be operated without increased risk for postoperative complications. Pregnancy-related outcomes are markedly improved.

Bariatric surgery results in significant improvements in all modalities of quality of life, especially in physical domains and in younger patients. The most important factors, besides weight decrease, were absence of preoperative medication for depression and postoperative complications. Regarding relationship status, an increased incidence of divorce and separation was seen, but also an increase in new relationships for patients who were single at the time of surgery. In our economic modulations, bariatric surgery seems to be cost saving. Despite the intentions of our healthcare system, we have revealed that low socioeconomic status was associated with reduced chance of having bariatric surgery, as well as more postoperative complications and inferior outcome concerning weight loss, diabetes remission, and improvements in quality of life.

Concerning the registry itself, all entries are done online, and our continuous validation process has demonstrated high acquisition rate, internal validity, and completeness. Moreover, we have been able to perform several RCTs within SOReg, by using the registry for both randomization and storage of study data.

In summary, we believe that the two aims of the SOReg, maintaining high-quality care in Swedish metabolic and bariatric surgery and providing a first-class database for research, have been fulfilled. We look forward to further development of the register, for example, by creating direct transfer of data from electronic patient charts and other digital medical records.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflicts of interest concerning the present work. However, all authors are on the steering committee for the Scandinavian Obesity Surgery Registry (SOReg), and MS is part of the project group for the National Guidelines for Obesity Care run by
the National Board of Health and Welfare, JO is a member of the Data Safety Monitoring Board for the BEST study, and ES has received speaker honoraria from Johnson & Johnson Medical.

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**SUPPORTING INFORMATION**

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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