Aims
The aims of this study were to describe the prevalence of previous lumbar surgery in patients who undergo total hip arthroplasty (THA) and to investigate their patient-reported outcomes (PROMs) one year post-operatively.

Patients and Methods
Data from the Swedish Hip Arthroplasty Register and the Swedish Spine Register gathered from 2002 to 2013 were merged to identify a group of patients who had undergone lumbar surgery before THA (n = 997) and a carefully matched one-to-one control group. We investigated differences in the one-year post-operative PROMs between the groups. Linear regression analyses were used to explore the associations between previous lumbar surgery and these PROMs following THA. The prevalence of prior lumbar surgery was calculated as the ratio of patients identified with previous lumbar surgery between 2002 and 2012, and divided by the total number of patients who underwent a THA in 2012.

Results
The prevalence of lumbar surgery prior to THA in 2012 was 3.5% (351 of 10 082). Linear regression analyses showed an association with more pain (B = 4.35, 95% confidence interval (CI) 2.57 to 6.12), worse EuroQol (EQ)-5D index, (B = -0.089, 95% CI -0.112 to -0.066), worse EQ VAS (B = -6.75, 95% CI -8.58 to -4.92), and less satisfaction (B = 6.04, 95% CI 4.05 to 8.02).

Conclusion
Lumbar spinal surgery prior to THA is associated with less reduction of pain, worse health-related quality of life, and less satisfaction one year after THA. This is useful information to share in the decision-making process and may help establish realistic expectations of the outcomes of THA in patients who also have previously undergone lumbar spinal surgery.

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would have worse outcomes following THA compared with those without previous lumbar surgery.

**Patients and Methods**

Surgical, demographic data and PROMs were obtained on patients with lumbar surgery or THA due to degenerative disorders by merging the Swedish Hip Arthroplasty Register (SHAR) \(^{15}\) between 2002 and 2013, and the Swedish Spine Register (Swespine) \(^{16}\) between 1998 and 2014. Degenerative disorders included primary OA of the hip, central or lateral lumbar canal stenosis, lumbar spondylosis or spondylolisthesis and segment-related pain (i.e. due to pain from a specific segment of the back, but without the radiological appearance of stenosis or spondylolisthesis).

Both SHAR which started in 1979, and Swespine which started in 1993, gather prospective observational data on all THAs and all surgical procedures to the spine performed in Sweden, at both publicly and privately funded hospitals. The completeness of registration has been reported to be 98.1% for SHAR \(^{15}\) and 85% for Swespine. \(^{16}\) The common identifier used in both registries is the unique personal identity number (PIN) given to all inhabitants in Sweden.

In 2002, SHAR launched a nationwide PROMs programme for patients undergoing an elective THA and reached full participation among Swedish orthopaedic departments in 2008. The purpose of the programme was to complement the traditional outcome variables, such as implant survival, with PROMs on pain, function and health-related quality of life. \(^{11}\) The PROMs programme invites all patients scheduled for an elective THA to complete a short questionnaire at their pre-operative visit. A follow-up survey is mailed to patients at one, six and ten years post-operatively. The frequency of response has been reported to be 86% pre-operatively and 90% at the one-year follow-up. \(^{17}\) The PROMs programme \(^{17}\) comprises a visual analogue scale (VAS) for pain in the hip, \(^{18}\) the Euro-Qol (EQ)-5D health status questionnaire \(^{19}\) and a VAS addressing satisfaction. The EQ-5D health status questionnaire is a commonly used instrument for the assessment of quality of life (HRQoL). \(^{20}\) It includes five dimensions, namely mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is covered by one question with three levels of severity: no problems, moderate problems and severe problems. The descriptive system yields 243 possible health states. By applying weights given by a specific set of values, each state can be transformed into a single index which serves as an overall measure of HRQoL. We used the United Kingdom time-trade-off value set to calculate the EQ-5D index. \(^{21}\) The second part of the EQ-5D contains a VAS addressing general health (EQ VAS) where 0 and 100 represent the worst and best possible health state, respectively. The pain and satisfaction VASs range from 0 to 100, where 0 represents no pain or satisfaction and 100 the worst possible pain or the greatest satisfaction. Two patient-reported items are also included to assess musculoskeletal comorbidity according to the Charney classification; class A and B correspond to a condition involving one or both hips, respectively, and class C involves limitation of mobility due to multiple joint involvement or other medical comorbidities. \(^{22}\) For the analyses in this study, we used PROMs collected by the SHAR as described in Patients and Methods above.

Patients with OA of the hip who had a THA during 2012 and were registered on Swespine as having had previous lumbar surgery were identified from 2002 to the date of the THA. For those who underwent bilateral THA during 2012, only the first hip was included. Only patients with first-time lumbar surgery for a degenerative disorder were selected from the database.

Based on the PIN, the databases were then merged and patients registered in both were identified. Those who were only registered in Swespine were excluded. Prevalence was calculated as the ratio of patients identified with previous lumbar surgery divided by the total number of patients with OA who had a THA in 2012 (Fig. 1).

A set of selection criteria in a step-wise fashion was applied in order to reduce heterogeneity. All diagnoses other than degenerative diseases were excluded as patients requiring THA following trauma or with rheumatoid arthritis would have a different demography and outcome. Only THAs undertaken using the lateral and posterior approaches were included, as these are the two predominant approaches used in Sweden. Resurfacing arthroplasties were also excluded as they are rarely used in Sweden, have a different biomechanical design and are usually undertaken in younger patients. Patients who had died or underwent further surgery within one year were also excluded.
LUMBAR SURGERY PRIOR TO TOTAL HIP ARTHROPLASTY IS ASSOCIATED WITH WORSE PATIENT-REPORTED OUTCOMES

All THA procedures 2002 to 2013 in SHAR n = 139 697

Contralateral hip excluded n = 18 130

Total number of patients with THA 2002 to 2013 n = 121 564

Exclusion if registered THA is second THA n = 12 258

Only THA or THA and LBS n = 109 306

Patients after selection criteria n = 63 971

No LBS prior to THA available for matching n = 62 974

Study group after selection of patients with LBS prior to THA n = 997

Selection of patients undergoing total hip arthroplasty (THA) with or without previous low back surgery (LBS) (SHAR, Swedish Hip Arthroplasty Register; Swespine, Swedish Spine Register; PROM, patient-reported outcome measure).

excluded as they lack one-year PROM data. Patients with no pre- or one year post-operative data were excluded (Fig. 2). By direct matching of age, gender, year of surgery, type of fixation, Charnley class, pre-operative EQ-5D index, EQ VAS, and VAS score, a one-to-one matched control group was selected.

Statistical analysis. Raw data were summarised as frequencies for categorical data and means and associated standard deviations for continuous data. Group comparisons were conducted with chi-squared test for categorical and student’s t-test for continuous variables. Post-operative PROM data were modelled with linear regression analysis with the post-operative value as outcome and lumbar surgery as exposure. The model was adjusted for age, gender and pre-operative PROM values. Pre-operative values were modelled in piecewise linear regression splines that correct, to a certain extent, the ceiling effect and with predicted post-operative values more likely in an appropriate range. The one-to-one matching was performed with a non-parametric matching method, nearest neighbour matching. Statistical analyses were performed in R (R Core Team, Vienna, Austria). Statistical significance was set at p < 0.05.

Ethical review approval was obtained from the Review Board in Gothenburg, Sweden, registration number 236-13.
Results
The prevalence of THA and previous lumbar surgery was 3.5%. This was calculated as the ratio of patients identified with previous lumbar surgery between 2002 and 2012 (n = 351) divided by the number of patients who underwent THA for OA of the hip in 2012 (n = 10 082). Of these patients, 40% (n = 139) had lumbar surgery less than two years before THA.

Between 2002 and 2013 a total of 139 697 THAs were registered in 121 564 patients in SHAR. Between 1998 and 2014, 47 433 lumbar spinal procedures were registered in Swespine, of which 43 767 were in patients with a degenerative spinal disorder (Fig. 2).

A total of 997 patients were identified for the study. The diagnoses in the patients with lumbar surgery prior to THA were; central stenosis (80%, n = 798), lateral spinal stenosis (12%, n = 120), spondylosis/spondylolisthesis (4%, n = 38) and segment related pain (4%, n = 41). For each patient, a matched control with no history of lumbar surgery was identified. The demographic details and pre-operative PROMs did not differ between the study group and the controls, except for the ‘usual activities’ dimension of the EQ-5D, in which the patients in the study group more frequently reported some or extreme problems (p < 0.001) (Table I).

One year after THA, patients with previous lumbar surgery reported more pain, worse EQ-5D index, worse health, according to the EQ VAS, and less satisfaction (all p < 0.001). In all EQ-5D dimensions except for the activity of daily living, the patients in the study group more frequently reported some or severe problems. The proportion of patients reporting impaired mobility due to multiple joint involvement or other medical comorbidities (Charnley class C), one year post-operatively, differed significantly between the groups (Table II).

Linear regression analyses showed that lumbar surgery prior to THA was associated with more pain (VAS), worse EQ-5D index, worse EQ VAS and less satisfaction (VAS) (Table III). In a separate regression analysis, no association was found between the time between lumbar surgery and the THA and PROMs one year after THA, adjusting for age (r = 0.11, p = 0.0001).

Discussion
We found that 3.5% of patients undergoing THA for OA of the hip had a previous history of lumbar surgery for a degenerative spinal condition. In an attempt to reduce confounding bias, we defined a study population of patients with lumbar surgery before THA, operated on between 2002 and 2013 with a matched control group of those undergoing THA with no previous history of lumbar surgery. This comparison showed that those who had undergone lumbar surgery before their THA generally had more pain, worse HRQoL and were less satisfied with the outcome of their THA one year after surgery.

These results are consistent with those of Jaurequi et al.14 Prather et al15 retrospectively identified patients who had undergone THA and who had been diagnosed with or

Table I. Demography and pre-operative patient-reported outcome measures in the study and control groups

<table>
<thead>
<tr>
<th></th>
<th>Study group (n = 997)</th>
<th>Matched control group (n = 997)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean yr of surgery (sd)</td>
<td>2010 (2.36)</td>
<td>2010 (2.38)</td>
<td>0.713</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>589 (59.1)</td>
<td>595 (59.7)</td>
<td>0.820</td>
</tr>
<tr>
<td>Men</td>
<td>408 (40.9)</td>
<td>402 (40.3)</td>
<td></td>
</tr>
<tr>
<td>Implant fixation method, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cemented</td>
<td>742 (74.4)</td>
<td>740 (74.2)</td>
<td></td>
</tr>
<tr>
<td>Uncemented</td>
<td>107 (10.7)</td>
<td>110 (11.0)</td>
<td></td>
</tr>
<tr>
<td>Hybrid</td>
<td>23 (2.3)</td>
<td>31 (3.1)</td>
<td></td>
</tr>
<tr>
<td>Reversed hybrid</td>
<td>125 (12.5)</td>
<td>116 (11.6)</td>
<td></td>
</tr>
<tr>
<td>Posterior surgical approach (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain VAS, mean (sd)</td>
<td>67.2 (14.0)</td>
<td>66.8 (15.5)</td>
<td>0.616</td>
</tr>
<tr>
<td>EQ-5D index, mean (sd)</td>
<td>0.29 (0.31)</td>
<td>0.29 (0.31)</td>
<td>0.895</td>
</tr>
<tr>
<td>Mobility, mean (sd)</td>
<td>1.98 (0.19)</td>
<td>1.97 (0.20)</td>
<td>0.415</td>
</tr>
<tr>
<td>ADL, mean (sd)</td>
<td>1.33 (0.50)</td>
<td>1.34 (0.51)</td>
<td>0.691</td>
</tr>
<tr>
<td>Usual activities, mean (sd)</td>
<td>1.92 (0.64)</td>
<td>1.83 (0.64)</td>
<td>0.001</td>
</tr>
<tr>
<td>Pain/discomfort, mean (sd)</td>
<td>2.59 (0.50)</td>
<td>2.58 (0.51)</td>
<td>0.790</td>
</tr>
<tr>
<td>Anxiety/depression, mean (sd)</td>
<td>1.56 (0.58)</td>
<td>1.57 (0.61)</td>
<td>0.547</td>
</tr>
<tr>
<td>EQ VAS, mean (sd)</td>
<td>47.9 (23.1)</td>
<td>48.1 (22.8)</td>
<td>0.859</td>
</tr>
</tbody>
</table>

*p statistical tests were conducted with a chi-squared test for categorical variables and student’s t-test for continuous variables sd, standard deviation; VAS, visual analogue score; ADL, activity of daily living; EQ, EuroQol
LUMBAR SURGERY PRIOR TO TOTAL HIP ARTHROPLASTY IS ASSOCIATED WITH WORSE PATIENT-REPORTED OUTCOMES

Table II. Post-operative patient-reported outcome measures in the study and control groups

<table>
<thead>
<tr>
<th></th>
<th>Study group (n = 997)</th>
<th>Matched control group (n = 997)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charnley class, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A 228 (22.9)</td>
<td>378 (37.9)</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>B 52 (5.2)</td>
<td>96 (9.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 717 (71.9)</td>
<td>523 (52.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain VAS, mean (SD)</td>
<td>20.4 (22.0)</td>
<td>16.1 (18.7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>EQ-SD index, mean (SD)</td>
<td>0.66 (0.29)</td>
<td>0.75 (0.24)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Mobility, mean (SD)</td>
<td>1.66 (0.48)</td>
<td>1.49 (0.51)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>ADL, mean (SD)</td>
<td>1.14 (0.38)</td>
<td>1.11 (0.33)</td>
<td>0.092</td>
</tr>
<tr>
<td>Usual activities, mean (SD)</td>
<td>1.45 (0.58)</td>
<td>1.30 (0.52)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Pain/discomfort, mean (SD)</td>
<td>1.86 (0.60)</td>
<td>1.70 (0.56)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Anxiety/depression, mean (SD)</td>
<td>1.37 (0.54)</td>
<td>1.28 (0.49)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>EQ VAS, mean (SD)</td>
<td>66.3 (22.8)</td>
<td>73.1 (20.2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Satisfaction VAS, mean (SD)</td>
<td>22.7 (24.9)</td>
<td>16.7 (20.2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Mean time between surgeries (range)</td>
<td>3.27 (0.33 to 14.42)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*statistical tests were conducted with a chi-squared test for categorical variables and student’s t-test for continuous variables

Table III. The effect of prior lumbar surgery on patient reported outcome measures (PROMs) one year after total hip arthroplasty (THA). Crude values are from equations regressing lumbar surgery on post-operative PROMs, adjusted values take into consideration pre-operative PROM values, age and gender. The table presents regression coefficients and associated 95% confidence intervals

<table>
<thead>
<tr>
<th></th>
<th>Crude</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain VAS</td>
<td>4.33 (2.53 to 6.12)</td>
<td>4.35 (2.57 to 6.12)</td>
</tr>
<tr>
<td>EQ-SD Index</td>
<td>-0.08 (-0.11 to -0.06)</td>
<td>-0.08 (-0.11 to -0.06)</td>
</tr>
<tr>
<td>EQ VAS</td>
<td>-6.79 (-8.68 to -4.90)</td>
<td>-6.75 (-8.58 to -4.92)</td>
</tr>
<tr>
<td>Satisfaction VAS</td>
<td>6.04 (4.05 to 8.03)</td>
<td>6.04 (4.05 to 8.02)</td>
</tr>
</tbody>
</table>

VAS, visual analogue scale; EQ, EuroQol

without lumbar spinal disorders and found that those without a spinal disorder had greater improvement in function and reduction in pain than those with a history of a spinal disorder. Bischoff-Ferrari et al25 and Quintana et al26 have also shown a correlation between low back pain and poor function and outcomes following THA. Musculoskeletal comorbidities also predispose to worse outcomes following THA, and following total knee arthroplasty (TKA).11-13,27

In our study, the largest difference between the study group and the controls was seen in the general health status, as measured with the EQ-5D. The tendency for the general health of patients who had previously undergone lumbar surgery not to improve to the same extent as the matched controls, could partly be related to the comorbidity and the generic nature of the EQ-5D which makes it more liable to detect such differences. The smaller degree of improvement in mobility in the group with previous lumbar surgery could be explained by decreased range of pelvic movement following lumbar surgery. The strong correlation between functional improvement and satisfaction reported by Judge et al28 in patients following THA and TKA suggests that failure to relieve symptoms in patients who have also had lumbar spinal surgery is because of their generalised degenerative conditions. The analysis of prevalence revealed that most patients with lumbar surgery prior to THA (40%, n = 139) had their lumbar surgery less than two years before THA. This suggests that their symptoms prior to spinal surgery may not have been alleviated by the surgery, and that their expectations from THA were too high. However, there were no significant differences in post-operative PROMs when the time between the operations was investigated separately.

It is clear, therefore, that the association between previous lumbar surgery and poorer outcomes after THA needs to be considered in the decision-making process prior to surgery, and would help patients to have realistic expectations of the procedures. These results do not address the issue of which order to perform THA or lumbar surgery in patients with co-existing degenerative disorders. It has been argued that the good results in general following THA encourage undertaking this procedure first3 and several authors have reported that back pain improves after THA.5,29-32 Others have shown that patients with persistent low back pain after THA improve after subsequent lumbar surgery.2,3 On the other hand, patients with spinal stenosis may be at risk of neurological complications such as foot-drop after THA.33 These patients are likely to be more susceptible to traction on the sciatic nerve or as a consequence of leg lengthening.6,33 For this reason, decompression of the lumbar spine may be indicated before THA in patients with symptomatic spinal stenosis. However, decompression of asymptomatic lumbar stenosis in order to prevent neurological complications following THA is not recommended.6,33
This study has limitations. The prevalence of previous lumbar surgery in patients undergoing THA could be considered a conservative estimate as some patients may have had lumbar surgery before 2002. In addition, only the prevalence of operations related to lumbar degenerative disease was recorded and not the total prevalence of degenerative disorders of the lumbar spine in patients undergoing THA. However, the large number of patients in the study group and the precise matching of patients add to the strengths of study. We not only matched demographic variables, year of surgery and details of the surgical approach, but also the patients’ level of pain, health-related quality of life and Charnley class. Data were also obtained from two national quality registers which reduces performance bias and contributes to the quality of the selection of the study and control groups.

The observational nature of data prevents making conclusions on causation. The analyses were restricted to investigate the outcomes of THA in patients with a history of lumbar surgery compared with matched controls without a history of lumbar surgery. Thus, we did not include further information about the presence or severity of symptoms related to a degenerative spinal disorder at the time of THA. Adjustments were not made for the influence of other musculoskeletal conditions such as OA of the knee or the presence of other arthroplasties. Most of the large number of patients who were excluded due to missing PROMs data had not been invited to participate due to the gradual adoption of the PROMs programme among orthopaedic centres.

Finally patients with disc herniation were not included because their demographic differs considerably from that of the patients undergoing lumbar surgery and THA who were evaluated in our study.

This study is the first to report combined data from an arthroplasty register with a spinal register. In the future we intend to further explore coexistent hip and spinal disorders and to undertake a similar analysis of patients with THA before lumbar spinal surgery, which combined with data from this study, will allow us to indicate which should be undertaken first, THA or lumbar surgery.

In conclusion, this observational register study showed that 3.5% of patients who underwent THA in 2012 had undergone lumbar spinal surgery during the 11-year period prior to their hip surgery, and that those who had undergone lumbar surgery before their THA generally had a poorer outcome.

Take home message:
- Lumbar spinal surgery prior to THA is associated with less reduction of pain, worse HRQoL and less satisfaction one year after THA.
- This information needs to be taken into account in the decision-making process prior to surgery and would help patients have realistic expectations on the outcomes of the procedures.

Author contributions:
T. Eneqvist: Designed study, Statistical analysis, Analysed and interpreted results, Contributed to and approved final manuscript.
S. Nemes: Designed study, Statistical analysis, Analysed and interpreted results, Contributed to and approved final manuscript.
H. Brisby: Analysed and interpreted results, Contributed to and approved final manuscript.
P. Fritzell: Analysed and interpreted results, Contributed to and approved final manuscript.
G. Garellick: Contributed to and approved final manuscript.
O. Rolfson: Designed study, Analysed and interpreted results, Contributed to and approved final manuscript.

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References

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