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Complications, reoperations, readmissions, and length of hospital stay in 34 639 surgical cases of lumbar disc herniation

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Aims

The aims of this study were to determine the rates of surgical complications, reoperations, and readmissions following herniated lumbar disc surgery, and to investigate the impact of sociodemographic factors and comorbidity on the rate of such unfavourable events.

Patients and Methods

This was a longitudinal observation study. Data from herniated lumbar disc operations were retrieved from a large medical database using a combination of procedure and diagnosis codes from all public hospitals in Norway from 1999 to 2013. The impact of age, gender, geographical affiliation, education, civil status, income, and comorbidity on unfavourable events were analyzed by logistic regression.

Results

Of 34 639 operations, 2.7% (95% confidence interval (CI) 2.6 to 2.9) had a surgical complication, 2.1% (95% CI 2.0 to 2.3) had repeat surgery within 90 days, 2.4% (95% CI 2.2 to 2.5) had a non-surgical readmission within 90 days, and 6.7% (95% CI 6.4 to 6.9) experienced at least one of these unfavourable events. Unfavourable events were found to be associated with advanced age and comorbidity.

Conclusion

The results suggest that surgical complications are less frequent than previously suggested. There are limited associations between sociodemographic patient characteristics and unfavourable events.

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Surgery for lumbar disc herniation is a well-recognized and effective treatment in properly selected patients.[1] Measuring rates of complications, reoperations, readmissions, and length of hospital stay contributes important information regarding the quality and costs of surgical and hospital care.[2,3] This information is valuable, not only in relation to general economic issues, cost-effectiveness, and the framing of clinical guidelines on a population level, but also for conversations between patients and clinicians when evaluating treatment options. The complication and reoperation rates may influence both physicians' recommendations and patients' final decisions, thus these rates need to be kept updated, accessible, and patient-personalized.[4,5]

Although the length of hospital stay has been decreasing steadily despite the trend of an increasingly old surgical population,[6,7] there are few reports of time trends relating to complication and reoperation rates. Large national medical databases offer an opportunity to research rare events, such as complications and reoperations, over a long-time period within a large sample of operative procedures.[8]

The primary objective of this study was to determine the rate of unfavourable events such as surgical complications, reoperations, and readmissions for patients undergoing surgery for lumbar disc herniation, over a 15-year period from 1999 to 2013. The secondary objective was to investigate the impact of age, gender, comorbidity, education, civil status, income, and regional health authority affiliation on the rate of such events.

Patients and Methods

Design. This was a longitudinal observation study using data from a national medical database and a national population register from 1999 to 2013.

Data source. Hospital administrative data were retrieved from a national database at the Norwegian Knowledge Centre for Health Services for

the years between 1999 and 2009, and from the National Patient Registry (NPR) for the years between 2010 to 2013. A detailed description of the methods employed in data collection is published elsewhere.[9] The data set contained medical and surgical procedures performed, final medical diagnosis at discharge, and patient comorbidity according to the Charlson Comorbidity Index.[10] The complications at discharge were coded by the physicians according to the International Classification of Diseases (ICD-10 Norwegian version)[11] for each hospital admission. It also included data on the date and time of hospital admission and discharge, as well as the name(s) of the hospital(s) involved. A unique national registration number connects Norwegian residents to a hospital stay and to the sociodemographic data found in the National Population Register and other databases, such as Statistics Norway. These data sources cover the whole Norwegian population and provide information on age, gender, civil status, income, education level, and residence for each individual patient. The merging of data from the hospitals and the National Population Register was performed using a unique 11-digit personal identifier assigned to each Norwegian citizen.

Norway, with a population of 4.9 million, has a large, government-funded national healthcare system divided and run by four regional health authorities: the South-Eastern, Western, Central, and Northern Health Regions. Prior to 2007, these public regional health authorities were responsible for almost all spinal surgery in Norway, but from 2007 the public sector was only responsible for an estimated 80% of lumbar disc surgery, due to the increase of private surgery.[12,13]

Study sample. The inclusion criteria for this study was patients older than or equal to 18 years of age discharged from Norwegian public hospitals following surgery for a herniated lumbar disc between 1 January 1999 and 31 December 2013. A detailed description of the patient selection and coding clarification is presented in Figure 1. Data were retrieved through identification of the relevant surgical procedure codes in the NPR, which employs the Norwegian version of the Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures (NCSP),[14] a surgical coding system used in most Nordic countries. To ensure that the selected NCSP codes were specific for lumbar disc herniation surgery and not for other lumbar disorders (e.g. spinal stenosis) only operations with an ICD-10 diagnosis code (Norwegian version) indicating disc herniation were included. Operations for cancer, trauma, spinal infection, ankylosing spondylitis, and vertebral fractures were excluded from the study.

Once the relevant herniated lumbar disc surgery was identified, each patient's subsequent hospital admissions were retrieved, including surgical complications and follow-up surgical procedures. To make sure that all the patients could be followed for potential readmissions, reoperations, and complications for at least 90 days, initial operations performed in the time period between 1 September 2013 and 31 December 2013 were omitted from the analysis, as were operations performed in the first 90 days of the study period. All relevant surgical procedures with an added NSCP code indicating a more complex procedure (such as fusions and disc prosthesis) were omitted from analysis (Fig. 1). The raw data set contained seven endoscopic procedures (NCSP code: ABC 07), which were not included in the study.

Definition of outcomes. Surgical complication: each patient was given one of the following ICD-10 complication diagnoses either upon initial surgical admission or upon readmission within 90 days: T81.0-T81.9, K91, N99, I97.8-9.

Reoperation: patients reoperated on within 90 days of initial surgery (immediate reoperation included).[15] The reoperations were found using the same NSCP codes as the study inclusion; however, additional NSCP codes indicating a more complex procedure (such as fusions and disc prosthesis) were included.

Non-surgical readmission: patients readmitted within 90 days of lumbar surgery with an ICD-10 diagnosis of disc herniation, without reoperation. Such readmissions are usually due to intractable postoperative neurogenic pain, need of a repeat MRI, lack of expected clinical improvement, or other complications.

Unfavourable event: surgery with a surgical complication, reoperation, or a non-surgical readmission. The rate of unfavourable events represents the overall rate of the patient experiencing a surgical complication, reoperation, or readmission for surgery. Each patient may experience more than one of the above, thus the sum of the three individual rates is higher than the rate of a single unfavourable event.

Prolonged hospitalization: a patient's total hospital stay exceeding six days from day of admission to hospital discharge. This cut-off was based on the authors' clinical experience and has been used previously discussed.[16] A hospital stay exceeding six days is judged highly indicative of issues such as intractable postoperative pain, other complications, need of a repeat MRI, poor general condition, or lack of expected improvement.

Statistical analysis and missing data. All data analyses were performed using SPSS version 24.00 (IBM Corp., Armonk, New York). The significance level was set to 5%. Continuous data were described with median and interquartile range (IQR) or mean and range. The 95% confidence intervals (CI) are shown for all estimates. Associations between pairs of categorical data were analyzed using the chi-squared test. Multivariate logistic regression analysis was used to investigate the association between the independent variables (age, gender, comorbidity, education, civil status, income, and regional health authority affiliation) and the dependent variable (unfavourable event: surgical complication, reoperation, or a non-surgical readmission). All independent variables were entered simultaneously, and all significant associations were described with odds ratios (OR) and 95% CI. The data set contains almost no missing data ($n < 20$), except for the sociodemographic data concerning income (19% missing) and education (8% missing). Therefore, no missing values were imputed.

Ethics. The study was approved by the Norwegian Data Inspectorate (2014/14413) and the Norwegian Regional Ethics Committee (2013/1662, REC south-east D). Individual patient consent was not required.

Results

Between 1999 and 2013, there were 34 639 herniated lumbar disc operations and 735 reoperations. Of the initial operations, 31 155 (90%) were coded as surgical discectomies and 3484 (10%) as surgical decompressions, for a total of

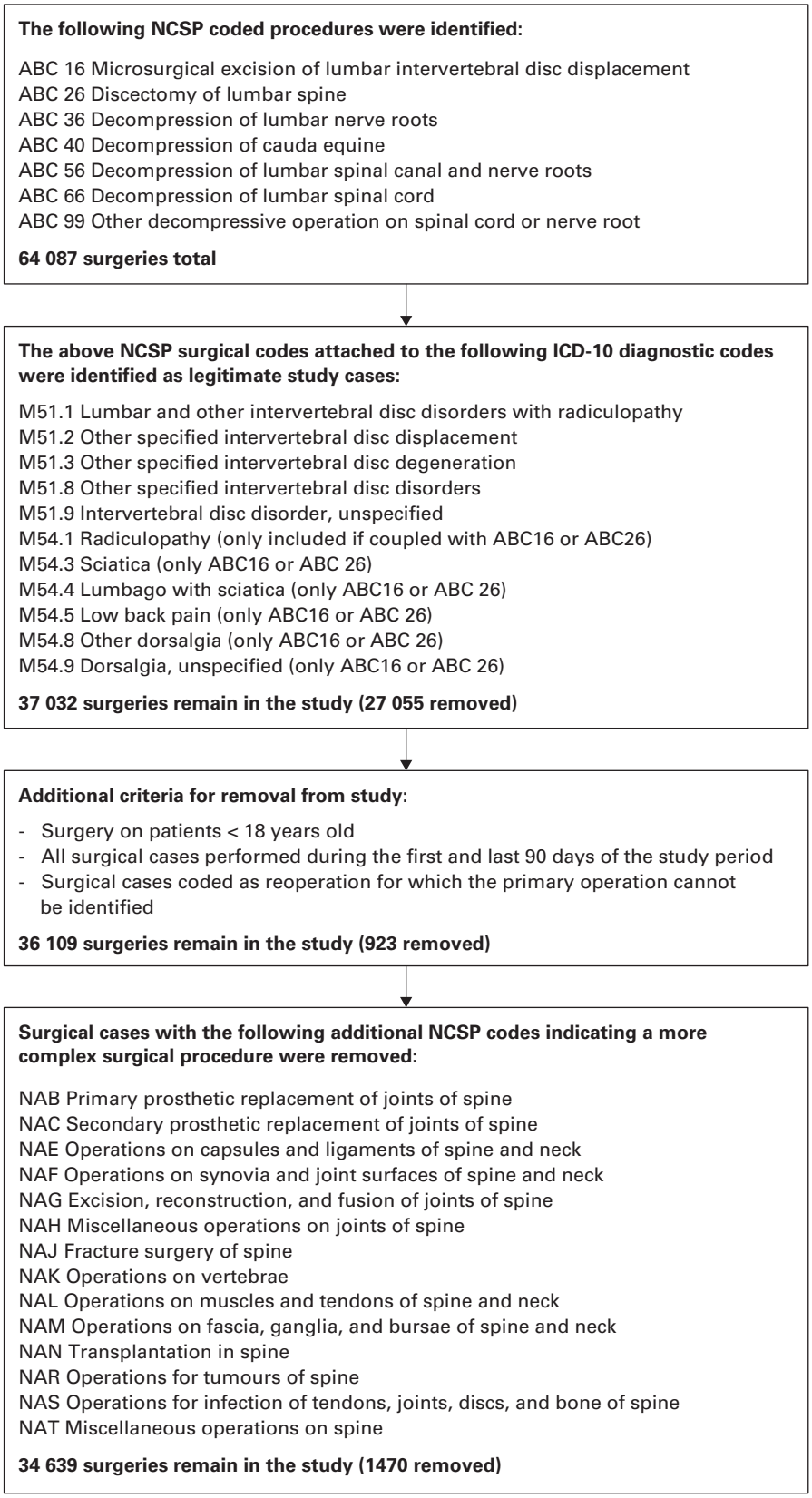

Fig. 1

Flow diagram of patient selection (NCSP, Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures; ICD, International Classification of Diseases).

Table I. Rates for hospital duration, complications, repeat surgery, and readmissions, according to the patient's age, gender, civil status, income, and year and region of operation

Variable	Procedures, n	Median hospital duration, days (IQR)	Prolonged hospitalization ≥ 7 days, % (95% CI)	Surgical complication, % (95% CI)	Repeat surgery ≤ 90 days, % (95% CI)	Readmission, no surgery ≤ 90 days, % (95% CI)*	Unfavourable event, % (95% CI)†
Total	34 639	4.1 (2.3 to 6.3)	*31.7* (*31.2* to *32.2*)	*2.7* (*2.6* to *2.9*)	*2.1* (*2.0* to *2.3*)	*2.4* (*2.2* to *2.5*)	*6.7* (*6.4* to *6.9*)
Age, yrs							
18 to 29	3336	3.7 (2.2 to 5.8)	*25.4* (*24.0* to *26.9*)	*1.7* (*1.2* to *2.1*)	*1.4* (*1.0* to *1.8*)	*2.1* (*1.6* to *2.6*)	*4.9* (*4.2* to *5.7*)
30 to 39	9362	4.1 (2.3 to 6.1)	*28.8* (*27.9* to *29.8*)	*2.4* (*2.1* to *2.7*)	*2.0* (*1.7* to *2.3*)	*2.3* (*2.0* to *2.6*)	*6.1* (*5.6* to *6.7*)
40 to 49	10 456	4.1 (2.3 to 6.2)	*31.2* (*30.3* to *32.1*)	*2.7* (*2.4* to *3.0*)	*2.6* (*2.3* to *2.9*)	*2.5* (*2.2* to *2.8*)	*7.4* (*6.9* to *7.9*)
50 to 59	6702	4.1 (2.4 to 6.7)	*32.8* (*31.7* to *33.9*)	*2.8* (*2.4* to *3.2*)	*2.0* (*1.7* to *2.4*)	*2.3* (*2.0* to *2.7*)	*6.5* (*5.9* to *7.1*)
60 to 69	3311	4.2 (2.3 to 7.1)	*35.0* (*33.4* to *36.7*)	*3.8* (*3.2* to *4.5*)	*1.9* (*1.4* to *2.3*)	*2.5* (*2.1* to *3.0*)	*7.6* (*6.7* to *8.5*)
70 to 79	1212	6.1 (3.2 to 10.1)	*52.1* (*49.3* to *55.0*)	*4.8* (*3.6* to *6.0*)	*2.2* (*1.3* to *3.0*)	*2.2* (*1.4* to *3.1*)	*8.3* (*6.8* to *9.9*)
≥ 80	260	7.2 (4.2 to 13.1)	*63.1* (*57.2* to *69.0*)	*6.2* (*3.2* to *9.1*)	*1.2* (*0.0* to *3.0*)	*2.3* (*0.5* to *4.1*)	*8.1* (*4.7* to *11.4*)
Gender							
Male	19 623	4.0 (2.2 to 6.1)	*28.9* (*28.3* to *29.6*)	*2.6* (*2.4* to *2.9*)	*2.0* (*1.8* to *2.2*)	*2.4* (*2.2* to *2.6*)	*6.5* (*6.2* to *6.9*)
Female	15 016	4.2 (2.8 to 7.1)	*35.2* (*34.5* to *36.0*)	*2.8* (*2.6* to *3.1*)	*2.3* (*2.0* to *2.5*)	*2.3* (*2.1* to *2.6*)	*6.9* (*6.5* to *7.3*)
CCI							
0	33 328	4.1 (2.3 to 6.2)	*31.2* (*30.8* to *31.7*)	*2.6* (*2.5* to *2.8*)	*2.1* (*1.9* to *2.2*)	*2.3* (*2.1* to *2.4*)	*6.5* (*6.2* to *6.7*)
1 to 2	1191	5.0 (3.1 to 8.2)	*40.9* (*38.1* to *43.7*)	*5.1* (*3.9* to *6.4*)	*3.3* (*2.3* to *4.3*)	*4.5* (*3.3* to *5.6*)	*11.3* (*9.5* to *13.4*)
≥ 3	120	6.1 (3.2 to 10.3)	*54.2* (*45.1* to *63.2*)	*1.7* (*0.0* to *4.0*)	*3.3* (*0.1* to *6.6*)	*6.7* (*2.1* to *11.2*)	*11.7* (*5.8* to *17.5*)
Education‡							
Basic	24 781	4.1 (2.3 to 6.3)	*31.8* (*31.2* to *32.4*)	*2.8* (*2.6* to *3.0*)	*2.1* (*1.9* to *2.3*)	*2.5* (*2.3* to *2.7*)	*6.8* (*6.5* to *7.1*)
Higher	7019	4.0 (2.2 to 6.2)	*29.8* (*28.7* to *31.0*)	*2.6* (*2.3* to *3.0*)	*2.3* (*2.0* to *2.6*)	*2.0* (*1.7* to *2.3*)	*6.5* (*5.9* to *7.1*)
Missing data	2839	4.2 (2.9 to 6.8)	*35.3* (*33.5* to *37.0*)	*2.3* (*1.7* to *2.8*)	*1.5* (*1.1* to *2.0*)	*2.3* (*1.8* to *2.9*)	*5.9* (*5.0* to *6.7*)
Civil status§							
Partner	16 573	4.1 (2.4 to 6.5)	*32.4* (*31.7* to *33.1*)	*2.6* (*2.4* to *2.8*)	*2.0* (*1.8* to *2.2*)	*2.2* (*2.0* to *2.4*)	*6.3* (*5.9* to *6.6*)
No partner	18 066	4.1 (2.3 to 6.2)	*31.0* (*30.3* to *31.6*)	*2.9* (*2.6* to *3.1*)	*2.3* (*2.0* to *2.5*)	*2.5* (*2.3* to *2.7*)	*7.0* (*6.7* to *7.4*)
Income, NOK¶							
< 125k	3915	4.2 (3.0 to 7.1)	*35.5* (*34.0* to *37.0*)	*2.5* (*2.0* to *3.0*)	*1.6* (*1.2* to *2.0*)	*2.9* (*2.4* to *3.5*)	*6.1* (*5.7* to *7.3*)
125k to 399k	17 024	4.1 (2.4 to 6.2)	*30.5* (*29.8* to *31.2*)	*2.7* (*2.4* to *2.9*)	*2.1* (*1.9* to *2.3*)	*2.3* (*2.1* to *2.5*)	*6.5* (*6.2* to *6.9*)
400k to 700k	5960	3.2 (2.1 to 5.2)	*23.3* (*22.2* to *24.4*)	*2.4* (*2.0* to *2.8*)	*2.5* (*2.1* to *2.9*)	*1.8* (*1.5* to *2.2*)	*6.2* (*5.6* to *6.9*)
> 700k	1283	3.1 (2.0 to 5.1)	*22.1* (*19.8* to *24.3*)	*3.3* (*2.3* to *4.3*)	*3.1* (*2.2* to *4.1*)	*1.9* (*1.1* to *2.6*)	*7.7* (*6.3* to *9.2*)
Missing data	6457	5.1 (3.1 to 8.0)	*42.0* (*40.8* to *43.2*)	*3.2* (*2.7* to *3.6*)	*1.9* (*1.6* to *2.3*)	*2.9* (*2.5* to *3.3*)	*6.5* (*6.2* to *6.9*)
Year							
1999 to 2001	7262	5.3 (3.9 to 8.0)	*46.6* (*45.5* to *47.8*)	*1.2* (*1.0* to *1.5*)	*1.3* (*1.1* to *1.6*)	*2.5* (*2.1* to *2.9*)	*4.8* (*4.3* to *5.2*)
2002 to 2004	7470	4.4 (3.1 to 7.1)	*37.0* (*35.9* to *38.1*)	*2.0* (*1.7* to *2.3*)	*1.6* (*1.3* to *1.9*)	*2.3* (*2.0* to *2.7*)	*5.5* (*5.0* to *6.0*)
2005 to 2007	6295	4.1 (2.7 to 6.2)	*30.1* (*28.9* to *31.2*)	*3.5* (*3.1* to *4.0*)	*1.9* (*1.5* to *2.2*)	*2.3* (*1.9* to *2.6*)	*7.0* (*6.4* to *7.7*)
2008 to 2010	6406	3.2 (2.1 to 5.2)	*23.6* (*22.6* to *24.6*)	*3.4* (*3.0* to *3.9*)	*2.5* (*2.1* to *2.8*)	*2.5* (*2.1* to *2.9*)	*7.7* (*7.1* to *8.4*)
2011 to 2013	7206	2.9 (2.0 to 5.0)	*19.6* (*18.7* to *20.5*)	*3.7* (*3.3* to *4.2*)	*3.4* (*3.0* to *3.8*)	*2.2* (*1.9* to *2.6*)	*8.6* (*7.9* to *9.2*)
Demographics**							
Region 1	19 643	4.1 (2.3 to 6.2)	*30.5* (*29.9* to *31.2*)	*2.9* (*2.7* to *3.1*)	*1.9* (*1.7* to *2.1*)	*2.3* (*2.1* to *2.5*)	*6.5* (*6.2* to *6.9*)
Region 2	9190	4.7 (3.1 to 7.1)	*36.6* (*35.6* to *37.6*)	*2.9* (*2.5* to *3.2*)	*2.1* (*1.8* to *2.4*)	*2.2* (*1.9* to *2.5*)	*6.6* (*6.1* to *7.1*)
Region 3	4468	2.8 (1.3 to 4.9)	*21.2* (*20.0* to *22.4*)	*1.7* (*1.4* to *2.1*)	*3.0* (*2.5* to *3.5*)	*2.7* (*2.3* to *3.2*)	*7.1* (*6.4* to *7.9*)
Region 4	1338	5.9 (3.8 to 8.1)	*49.0* (*46.4* to *51.7*)	*3.0* (*2.1* to *3.9*)	*1.8* (*1.1* to *2.5*)	*3.3* (*2.3* to *4.3*)	*7.6* (*6.2* to *9.1*)

*Patient was readmitted within 90 days of lumbar surgery with a lumbar diagnosis, but was not reoperated

†Surgical complication, repeat surgery ≤ 90 days from discharge, or a readmission within 90 days of lumbar surgery (lumbar diagnosis, no reoperation)

‡Basic education = high school/vocational education; higher education = college/university for three or more years

§Partner = living registered partner or spouse

¶NOK = Norwegian currency: 1NOK ≈ US$0.12 ≈ £0.10; < 125k = low 10% percentile, 400k = median, > 700k = top 10% percentile

**Region 1 = South-Eastern Health Region; region 2 = Western Health Region; region 3 = Central Health Region; region 4 = Northern Health Region

IQR, interquartile range; CI, confidence interval; CCI, Charlson Comorbidity Index

30 961 individual patients. Microdiscectomy was specified in 23 929 patients (69%); the remaining 10 710 (31%) were specified neither as microdiscectomy or standard/open procedures.

The annual public hospital surgery rate was stable throughout the course of the study, with an average of 50 lumbar disc operations per 100 000 Norwegian inhabitants.

Table I shows rates of unfavourable events according to patient characteristics and year of operation. The patients' mean age was 45 years (18 to 92) and the median duration of hospitalization was 4.1 days (IQR 2.3 to 6.3). There was a decrease in median hospitalization from 5.3 days (IQR 3.9 to 8.0) to 2.9 days (IQR 2.0 to 5.0) during the course of this study. The mean age increased from 42.9 years (18 to 87) to 46.6 years (18 to 92)

Table II. Surgical complications within 30 days after 34 639 herniated lumbar disc surgeries*

ICD-10 codes	Description of complication	Operations, n	Percentage of all operations (n = 34 639)
T81.2	Unintentional dural puncture/laceration	376	*1.1*
T81.4	Infection following a procedure	179	*0.5*
T81.0	Bleeding or haematoma	172	*0.5*
T81.8-9	Unspecified and other complications of procedure	134	*0.4*
T88.4-5	Complications during anaesthesia	47	*0.1*
T81.3	Disruption of wound/wound dehiscence	20	*< 0.1*
T81.1	Post-procedural shock	5	*< 0.1*
T81.5	Foreign body accidentally left in body following procedure	4	*< 0.1*

*In no patients were the following complications identified: T81.6, acute reaction to foreign body accidentally left during a procedure; T81.7, vascular complications following a procedure; K91, post-procedural disorders of the digestive system; N99, post-procedural disorders of the genitourinary system; G97.8-9, post-procedural disorder of nervous system; I97.8-9, post-procedural disorder of the circulatory system

ICD, International Classification of Diseases

and the proportion of patients over 60 years of age gradually increased from 7.3% (95% CI 6.7 to 7.9) in the first three years to 17% (95% CI 16.5 to 18.2) in the last three years. There were 7% more operations on male than female patients during the study period. The rate of experiencing an unfavourable event (complication, reoperation, or a readmission) was 6.7% (95% CI 6.4 to 6.9). The rate was 6.4% (95% CI 5.9 to 6.9) in operations coded specifically as microdiscectomy and 6.8% (95% CI 6.5 to 7.1) among the remaining, not specified as microdiscectomy or standard/open. No patients died during an operation or within 30 days after hospital discharge.

About one-third of the patients (35% female and 29% male) experienced a prolonged period of hospitalization which increased with the patient's age. Overall, however, there was a decrease in the period of hospitalization over time. Only 3% of the operations were performed on patients with one or more comorbidity according to the Charlson Comorbidity Index. These operations had a significantly higher proportion of prolonged hospitalization, compared with operations on patients with no prior comorbidity.

The surgical complication rate was 2.7% (95% CI 2.6 to 2.9), with 30% being identified on readmission. The most common surgical complications were dural tears/punctures, infections, and haemorrhages (Table II). There were no obvious gender differences, but the complication rate increased with the patient's age and comorbidity. The complication rate was significantly lower in the study's first six years, 1.6% (95% CI 1.4 to 1.8), compared with the following nine years, 3.5% (95% CI 3.2 to 3.8).

The rate of repeat surgery was 2.1% (95% CI 2.0 to 2.3), 14% of the reoperations being performed during the initial admission and the remaining 86% within 90 days of hospital discharge. A total of 14% of the reoperations were coded as reoperations due to a surgical complication, but no cause was specified in the remaining 86%. Age did not significantly impact the rate of repeat surgery, but the rate was higher in patients with prior comorbidities. From 1999 to 2013, there was an increase in the reoperation rate from 1.3% (95% CI 1.1 to 1.6) to 3.4% (95% CI 3.0 to 3.8). In total, 1856 of all operations (5.4%) were followed by a second operation within a year of initial discharge.

The rate of non-surgical readmissions within 90 days was 2.4% (95% CI 2.2 to 2.5). The rate was not significantly affected by stratifying by age, gender, type of operation, or year of surgery (Table I), but was higher amongst patients with prior comorbidities.

Table III shows the impact of patient comorbidity, sociodemographic factors, and the year of operation on unfavourable events, analyzed with logistic regression modelling. The model showed significant p-values, but, at the same time, low OR (95% CI) for the following factors: 40 to 59 years of age (age 18 to 39 as reference group), greater than or equal to 60 years of age, and comorbidity according to the Charlson Comorbidity Index. There was a statistically significant association and an increase in OR in patients when operated on between the years 2005 to 2007, 2008 to 2010, and 2011 to 2013 (with the years between 1999 to 2001 used as the reference group).

A total of 151 patients were admitted to hospital within 30 days after surgery with medical conditions that may be complications of lumbar surgery, but their hospital stays were not registered as such (Table IV). Their readmissions and medical conditions were, therefore, not included in the study's complication rate analysis. However, if these readmissions are considered as a complication of the patient's lumbar disc surgery, the overall complication rate was 3.2% (95% CI 3.0 to 3.4).

Discussion

In this study of 34 639 herniated lumbar disc operations performed over a 15-year period, 2.7% had a surgical complication, 2.1% had a repeat surgery, 2.4% had a non-surgical readmission, and 6.6% had at least one of these unfavourable events (surgical complication, repeat surgery, or a non-surgical readmission). There was a slight increase in complication rates over the course of the study. Unfavourable events were found to be significantly associated with advanced age and comorbidity but there was limited association with other sociodemographic characteristics such as gender, geographical affiliation, education, civil status, and income.

The present study has several strengths, one being that the data set represents almost all operations for lumbar disc herniation carried out through the public health system in Norway during the defined period. There was, therefore, no selection bias in terms of only using procedures performed by specific surgeons or hospitals.[17] Thus, the study was independent of surgeons' and hospitals' prior experience, competence, and general willingness to take part in the study. Private sector procedures

Table III. Multivariate logistic regression model showing the associations of sociodemographic factors, comorbidity, and year of operation on the occurrence of unfavourable events in lumbar disc surgery

Patient characteristics, predictors	OR for an unfavourable event (95% CI) (n = 27 872)	p-value
Age group, yrs		
18 to 39	1	Referent
40 to 59	1.23 (1.11 to 1.37)	< 0.001
≥ 60	1.22 (1.02 to 1.48)	0.03
Female gender	1.06 (0.96 to 1.17)	0.23
Comorbidity (a score of ≥ 1 according to the Charlson Comorbidity Index)	1.62 (1.27 to 2.06)	< 0.001
Education (basic education only, high school/vocational education)	1.06 (0.95 to 1.19)	0.30
Civil status (no living registered partner or spouse)	1.18 (0.98 to 1.41)	0.09
Low income*	1.05 (0.91 to 1.21)	0.53
Demographics (health regions in Norway)		
South-Eastern	1	Referent
Western	0.97 (0.87 to 1.09)	0.61
Central	1.10 (0.95 to 1.27)	0.19
Northern	1.23 (0.96 to 1.56)	0.10
Year of operation		
1999 to 2001	1	Referent
2002 to 2004	1.17 (0.98 to 1.40)	0.08
2005 to 2007	1.50 (1.28 to 1.75)	< 0.001
2008 to 2010	1.61 (1.38 to 1.89)	< 0.001
2011 to 2013	1.84 (1.59 to 2.15)	< 0.001

*< 125 000 NOK yearly income in the year prior to surgery. This number represents the lowest 10% percentile of the Norwegian population median; NOK = Norwegian currency, 1 NOK ≈ US$0.12 ≈ £0.10
OR, odds ratio; CI, confidence interval

Table IV. Description, number, and frequency of medical conditions not registered as complications of surgery, but leading to hospital readmission within 30 days of initial discharge*

Description of medical condition	Admissions, n (n = 151)	Percentage of all operations (n = 34 639)
Unspecified abdominal/chest pain	26	*0.08*
Cystitis	19	*0.05*
Pneumonia	10	*0.03*
Pulmonary embolism	9	*< 0.03*
Arrhythmia	8	*< 0.03*
Gastroenteritis	7	*< 0.03*
Sepsis	6	*< 0.03*
Heart attack	6	*< 0.03*
Gastrointestinal ulcer	5	*< 0.02*
Cholelithiasis	5	*< 0.02*
Headache	5	*< 0.02*
Urolithiasis	5	*< 0.02*
Skin infection	5	*< 0.02*
Brain infarct	4	*< 0.02*
Intraspinal abscess	4	*< 0.02*
Appendicitis	4	*< 0.02*
Deep venous thrombosis	3	*< 0.01*
Subarachnoid haemorrhage, epilepsy, delirium, depression/ anxiety, transient ischemic attack, dehydration, diabetes, lung abscess, pneumothorax, pancreatitis	≤ 2	*< 0.01*
Total	151	*0.4*

*Since these conditions have not been coded directly as complications to surgery, it is not possible to know with certainty whether these medical conditions were, or were not, related to the surgical procedure

accounted for 20% of the lumbar disc operations in Norway during the second half of the study period (2007 to 2013) but hardly any private surgery was performed during the first half (1999 to 2006). Private surgical patients are on average both younger and healthier than patients operated through the public sector.[12] This introduces a selection bias in the years 2007 to 2013, in that the public sector (the subject of this study) is left with a greater proportion of patients with a higher risk of unfavourable events.

Except for data concerning income and education, almost no data were missing, and there is little reason to doubt the accuracy of time of admission and discharge, as their registration falls under the legal responsibilities of the hospital system as a prerequisite for reimbursement. No information regarding the identity of the surgeons was recorded, thus there is no obvious incentive for a physician to not record complications. Nevertheless, the accuracy and completeness of the diagnostic and complication coding is difficult to assess, due to potential variation in the coding practices, experience, and thoroughness of physicians and surgeons. It is, therefore, important to acknowledge that the diagnostic codes may not accurately reflect what was documented in the patients' medical records.[18] Moreover, the data set provided no information regarding prior lumbar surgery outside the study period, a factor known to influence reoperation rates.[19]

Although the number of comparable studies is limited, their estimates and trends are similar to those revealed in the present study. The median length of hospital stay for lumbar surgery continues to decrease in Scandinavia.[6] The 90-day reoperation rate is 1% to 3% and can be associated with the rate of complications.[15] The elderly are more prone to complications,[20] of which most common complications are dural tears/punctures, infections, and haemorrhage.[16]

Bearing in mind that complications tend to be under-reported by health care workers,[21] the present study's mean surgical complication rate was generally (but not exclusively (1.6%))[22] lower than the rate reported in other studies (5.7%, 3.9%, 3% to 5%, and 5%).[16,20,23,24] Despite improvements in surgical techniques and hospital care that evolved during the study period, the especially low complication rate of 1.6% for the first six years of the study compared with the more commonly reported rate of 3.5% for the remaining nine years may be explained by the increase of private surgery along with the general trend of operating on older patients. Moreover, the present study only accounted for surgical complications that occurred during primary hospitalization or complications that led to a subsequent hospital readmission. It is quite possible that minor complications were treated in General Practice, without being recorded in the NPR, which might also explain the low surgical complication rate. Furthermore, we did not include discectomies and decompressions undertaken for more comprehensive procedures such as a spinal fusion or disc prosthesis surgery. Previous studies have included a range of different surgical procedures for lumbar disc herniation, which could explain their slightly higher rates of surgical complications and mortality (0.5%,0.7%, 0.8%).[5,6,23]

The low ORs in the logistic regression model suggest that advanced age and comorbidity contribute only a small additive increment to the risk of an unfavourable event. However, in our study, patients were all carefully selected for surgery with the general understanding that age and comorbidity will influence their surgical outcome. Thus, the study's comorbid and elderly patients may have a higher level of physical health than the elderly and comorbid in the general population. Therefore, the ORs may be misleadingly low, and age and comorbidity to be greater influencers of non-favourable events than our data suggests.

The present study showed that surgery for lumbar disc herniation has very low mortality (< 0.001%) and fewer than 7% of patients experience an unfavourable event such as a reoperation, complication, or readmission. Whether this rate is acceptable must be considered in relation to the health gains achieved, but patients can in general be informed that lumbar disc surgery is safe, although advanced age and comorbidity may slightly affect the complication rate. While the readmission and reoperation rates presented in the article are very accurate, the surgical complication rates may unfortunately be falsely low due to under reporting by the hospital physicians and surgeons.

Take home message

- To our knowledge, this is the largest study that specifically quantifies these unfavourable events over such a large sample size.
- We believe that these updated rates are important from a health-economic perspective and in relation to the conversations between patient and surgeon that take place in daily clinical practice.

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