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Concurrent changes in disability caused by back and neck pain after lumbar spine surgery: a multigroup trajectory analysis

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Abstract

Background Neck and back pain often occur simultaneously. The interconnection between their development after lumbar spine surgery has been studied little. This study aimed to assess the concurrent changes in back and neck pain and disability after lumbar spine surgery.

Methods 1627 patients undergoing lumbar spinal surgery responded to a survey before surgery and up to 2 years after. Group-based trajectory analysis and multinomial regression analysis were used.

Results The average age was 61.1 years and 53% were women. Concerning simultaneous changes in back and neck pain, two groups were identified. 82% experienced moderate preoperative back and no neck pain with quick and enduring pain relief after surgery. 18% with moderate preoperative pain in back and neck showed only a slight temporary postoperative pain relief. Three trajectory groups were identified based on changes in functional capacity. Group 1 (56%) had moderate disability caused by back pain (32.7%) and minimal disability caused by neck pain (15.7%) before surgery, which improved to 8.8% and 8.0% at 2 years. Group 2 (33%) had severe disability caused by back pain (48.4%) and moderate disability caused by neck pain (36.4%) before surgery, with postoperative values of 31.1% and 27.8%. Group 3 (11%) included patients who were housebound due to back pain (64.9%) and had severe disability caused by neck pain (56.7%); this group showed little improvement in disability after 2 years of follow-up. The higher probability of being classified into groups with worse outcomes was associated with female sex (RRR 1.54), a longer duration of preoperative pain (RRR 1.54 to RRR 1.51), older age (RRR 1.30) and higher BMI (RRR 1.44).

Conclusion For most of the patients, neck pain was not a major problem, but disability due to neck pain was common. It is possible that this disproportion was real, and the patients undergoing lumbar spine surgery experienced limitations caused by neck pain. It is also possible that this was due to the similarity of the Neck Disability Index and the Oswestry Disability Index. However, it seems that postoperative changes in neck and back pain and the injury caused by either of them may be related and should be considered at least in some patient groups.

Keywords Decompression, surgical, Pain measurement, Disability evaluation, Treatment outcome, Diskectomy

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Background

Changes in back and leg pain as well as changes in disability caused by this pain are expected and they are often observed after lumbar spine surgery [1–13]. It has been generally accepted that most patients might show beneficial effects of surgery in terms of pain reduction and disability facilitation. However, there is conflicting information about the magnitude, direction, and timing of these changes [13, 14]. It is self-evident that for some patient groups, trajectories of postoperative changes in pain and functioning may deviate substantially from trajectories of average changes in the studied populations. To describe this fact, Group-Based Trajectory Analysis (GBTA) has previously been used to compare changes in back and leg pain and functioning after lumbar spine surgery. While previous studies have observed some improvements in most of the patients, smaller groups did not exhibit recovery [14–16]. For example, Wang et al., studying patients undergoing lumbar discectomy, have found three clusters with different trajectories of changes in back and leg pain and disability [16]. For all three variables, 25–30% of the patients formed groups with poor outcomes.

Previous studies have found that greater preoperative pain predicts worse postoperative pain [1, 15]. In previous studies, female sex has been associated with greater pain and worse disability preoperatively [2]. Some studies have reported that women benefit as much, or even more, from surgery than men [3, 4]. Several studies have stated that age does not affect the surgical outcome [7, 8]. However, other studies have observed an increase in the probability of poorer postoperative functioning with older age [5, 6]. The same uncertainty exists for other potential risks for worse outcome of surgery. While some studies have stated that higher BMI does not affect the surgical outcome [10, 11], others have reported higher BMI being associated with worse results [9]. Previous studies have found that a longer duration of preoperative back pain could increase the probability of a worse surgical outcome [5, 6]. Clarifying these variations could aid clinical decision-making regarding the best treatment approach and also guide individualized preoperative interventions targeting modifiable risk factors to optimize patient outcomes [17].

Most of the previous reports on the matter are limited to describing changes in symptoms originating in the lumbar spine. Changes in symptoms occurring in other areas of the body after surgery have been studied only a little. It is well known that spine degeneration is often widespread, and when there are degenerative changes in the lumbar spine region, similar changes may likely be found also elsewhere in the spine, such as at cervical level [18, 19]. A connection between back and neck pain is well described [20–23]. A few studies have monitored changes in pain and disability after cervical surgery in patients with tandem stenosis both in the cervical and lumbar spine [24–26]. Alvin et al. have reported that after cervical surgery neck pain reduced but back pain did not [24]. Felbaum et al. have seen that back pain was relieved after cervical surgery, concluding that stenosis of the neck region may also mimic symptoms that are usually expected in lumbar stenosis, and surgery in the cervical region may relieve these symptoms [26]. Pennington et al. have concluded that in tandem stenosis, surgery on the lumbar spine alone may relieve the symptoms of both cervical and lumbar stenoses as if both areas have been operated on [27]. Cao et al. have observed a small group of patients, who experienced improvement in neck pain after lumbar spine surgery, observing a change in pain and disability measured with both Oswestry Disability Index (ODI) and Neck Disability Index (NDI) [28].

Spinal pain management generally requires a resource-intensive multidisciplinary approach to care and rehabilitation [29]. The high prevalence of back pain and the significant impairment of functional capacity it causes require the introduction of both massive traditional treatment lines and new and sometimes very special treatment methods [30–37]. Among such special and limitedly investigated methods is for example Graston technique [38]. When conservative treatment is failed, patients are often treated surgically, microendoscopic microdiscectomy being probably the most effective and safe technique [39]. It is unclear which factors can increase the effectiveness of spinal pain treatments. It has been suggested, among other things, that age and body mass index may have a limited impact on physiotherapy treatment outcomes in patients with spinal pain [40]. Also, baseline pain and functional limitations were suggested as important predictors of health-related quality of life and physiotherapy outcomes. In a study comparing pain, functional limitation, disability, and quality of life in women and men with cervical radiculopathy, some sex-related differences have been found [41]. It seemed that disability and quality of life were worse among women. Relationship between neck and arm pain, numbness, disability, and quality of life have been reported for patients with cervical spondylotic radiculopathy [42].

Some previous research has underscored the importance of considering psychological factors in pain management and highlight the potential utility of targeting emotion regulation strategies in clinical interventions [43, 44]. It has previously been suggested that generalized sensory hypersensitivity can occur in certain patient groups with spinal pain [45]. It is self-evident that such hypersensitivity can occur regardless of whether the main source of pain is located in the lumbar or cervical spine.

Thus, concurrent changes in neck and back pain and disability caused by pain in either region after lumbar spine surgery are poorly known. Based on previous limited evidence, it may be assumed that developmental trajectories of these concurrent changes may be dissimilar in different patient groups. The objective was to assess the concurrent changes in back and neck pain and disability caused by pain in either region after lumbar spine surgery. Another objective was to identify correlations between some descriptive factors and the probability of being classified to a certain trajectory group.

Methods

The study cohort consisted of all consecutive patients undergoing lumbar spinal surgery of any kind in a university hospital between June 21, 2018, and August 17, 2021. The patients responded to a repeated survey a) within two months before the surgery (baseline wave #1); two to four months after the surgery (wave #2); 11–13 months after the surgery (wave #3); and 23 to 25 months after the surgery (wave #4). The survey contained questions on demographics and the severity of disability and pain. A patient was included if the procedure code was one of the following: ABC07 "Percutaneous endoscopic discectomy for lumbar intervertebral disc displacement", ABC16 "Microsurgical excision of lumbar intervertebral disc displacement", ABC26 "Open discectomy of lumbar spine", ABC36 "Decompression of lumbar nerve roots", ABC56 "Decompression of lumbar spinal canal and nerve roots", ABC66 "Decompression of lumbar spinal cord", NAG61 "Posterior fusion of lumbar spine without fixation", NAG62 "Posterior fusion of lumbar spine with fixation, 2–3 vertebrae", NAG63 "Posterior fusion of lumbar spine with fixation, more than 3 vertebrae", NAG66 "Posterior interbody fusion of lumbar spine, 2 vertebrae", NAG67 "Posterior interbody fusion of lumbar spine, more than 2 vertebrae", and "NAJ32 Posterior reduction of fracture of lumbar spine", according to the Nordic Classification of Surgical Procedures (NCSP), version 1.15. All the patients, who had undergone more than one procedure during the follow-up, were excluded. The study was register-based (FinSpine), and the data were derived from an electronic patient record [46]. As stated by the country law and the ethical board of the university hospital district in question, such a study does not require explicit approval by an ethical board.

Table 1 Items of Oswestry disability index (ODI) and neck disability index (NDI)

Items	ODI	NDI
1	Pain intensity	Pain intensity
2	Personal care	Personal care
3	Lifting	Lifting
4	Walking	Reading
5	Sitting	Headaches
6	Standing	Concentration
7	Sleeping	Work
8	Sex life	Driving
9	Social life	Sleeping
10	Travelling	Recreation

The ODI describes disability caused by low back pain. The NDI is a modification of the ODI that measures disability caused by neck pain [47]. Both the ODI and NDI contain 10 items (Table 1). Each item is assessed on a six-level ordinal scale with "0" describing "no limitation" and "5" describing "extreme limitation or an inability to function" [48, 49]. The total score is a percentage calculated by the sum of all answers divided by 50 (the maximum possible number of points) and multiplied by 100 as follows: "Total score = (∑item scores/50) x 100". A score of 0% represents the highest possible level of functioning and independence, whereas a score of 100% represents the lowest possible level of functioning with total dependence. The total scores of the ODI and the NDI results were interpreted as follows: 0–20 points: "minimal disability", 21–40 points: "moderate disability", 41–60 points: "severe disability", 61–80 points: "housebound", and 81–100 points: "bedbound" [49, 50].

Pain intensity was assessed using a visual analog scale (VAS) from 0 to 100 points, with 0 indicating "no pain" and 100 indicating the "worst possible pain". The VAS results were interpreted as follows: 0–4 points: "no pain"; 5–44 points: "mild pain"; 45–74 points: "moderate pain"; and 75–100 points: "severe pain" [51].

Age was defined in full years at the time of surgery. For the main analysis, the sample was divided into two equal age groups of 813 (mean 48.4, SD 11.7 years) and 814 patients (mean 73.7, SD 5.7 years). Correspondingly, the preoperative duration of pain was dichotomized as < 3 months vs. ≥ 3 months and BMI was dichotomized as < 30 kg/m^2 vs. ≥ 30 kg/m^2.

Statistical analysis

The developmental trajectories of changes in back and neck pain as well as the disability caused by back or neck pain were studied using multigroup trajectory analysis. The conventional method of studying change over time evaluates development by measuring average change within a sample. However, populations are often heterogeneous, and individual trajectories can significantly differ from the average trend. The goal of group-based trajectory analysis is to pinpoint clusters with similar developmental paths within this diversity. After identifying groups with similar changes over time, the probability of being classified in a particular group can be calculated based on some relevant factors. Group-based trajectory analysis is useful also in situations when there are missing responses to repeated measures. This method is able to use all the available data including also cases with responses at only some measurement points. Certainly, this ability means that group-based trajectory analysis produces results showing trends at different measurement points and not the exact situation in a sample where all the measurements for all the participants are complete. Thus, the method allows to show trends in changes in studied variables at different cross-sections of repeated measures follow-up.

The number of clusters and the order of regression were determined by running all available combinations from one to four clusters and from first-order (linear) to third-order (cubic) regression models. The highest possible regression order (1st, 2nd, or 3rd) with a significant p value < 0.05 was chosen. The goodness of fit of a chosen model was confirmed by calculating the Bayesian Information Criterion (BIC) and the Akaike Information Criterion (AIC), preferring estimates closest to zero. Additionally, the cut-off for the Average Posterior Probability (APP) was set at 0.7, and the cut-off for the smallest possible cluster was set to 10%. Thus, two-cluster models were used for back and neck pain, while three-cluster models were employed for the disability caused by back and neck pain. The logic behind the determining the number of clusters is shown in Additional file 1. The models chosen and their goodness of fit are presented in Additional file 2.

It is possible that older patients might potentially receive more extensive surgeries e.g., due to a higher prevalence of degenerative deformities including cervical spine level. To investigate this possibility, a sensitivity analysis was performed comparing the initial situation of older and younger patients and the surgical methods used. The sample was divided into two groups based on the age of the patients < 60 years vs. >=60 years". Another sensitivity test was performed comparing the baseline characteristics of men vs. women. The third sensitivity test was conducted comparing the baseline characteristics of patients with longer vs. shorter duration of preoperative back pain.

After identifying clusters, the probability of group membership was calculated based on sex, age group, the duration of pain before surgery, and BMI by using multinomial regression analysis. This probability was expressed as a Relative Risk Ratio (RRR) along with its 95% confidence interval (95% CI). All the analyses were conducted using Stata/IC Statistical Software: Release 18, College Station (StataCorp LP, TX, USA).

Table 2 Descriptive characteristics of the study sample at baseline

Variables	Mean	Standard deviation
Age (entire sample), years	61.1	15.6
Age group 1 (n = 813), years	48.4	11.7
Age group 2 (n = 814), years	73.7	5.7
Body mass index, kg/m^2	28.7	5.1
Back pain intensity, points	59.5	26.9
Leg pain intensity, points	64.1	26.7
ODI [a] total score, points	43.4	16.5
NDI [b] total score	28.3	17.4
	N	**%**
Sex		
Female	856	53%
Male	771	47%
Pain duration before surgery		
< 3 months	804	49%
>=3 months	823	51%
Surgery codes [c]		
ABC16 Microsurgical excision of lumbar intervertebral disc displacement	411	25%
ABC36 Decompression of lumbar nerve roots	327	20%
NAG62 Posterior fusion of lumbar spine with fixation, 2–3 vertebraea	321	20%
ABC56 Decompression of lumbar spinal canal and nerve roots	306	19%
Others	192	12%
Main diagnoses [d]		
M48 Spondylopathies	682	42%
G55/M51 intervertebral disc disorders	552	34%
M43 Deforming dorsopathies	196	12%
M47 Spondylosis	102	6%
Others	95	6%

[a] Oswestry Disability Index; [b] Neck Disability Index; [c] Nordic Classification of Surgical Procedures NCSP; [d] International Classification of Diseases ICD-10

RESULTS

The preoperative surveys were completed by 1627 patients (Table 2). Mean age was 61.1 (SD 15.6) years, and 856 (53%) were women. Mean BMI was 28.7 (SD 5.1) kg/m^2. Of the patients, 823 (51%) experienced pain three or more months preoperatively. The most frequent reason for surgery was "ABC16 Microsurgical excision of lumbar intervertebral disc displacement" (25%) and the most frequent diagnosis was "M48 Spondylopathies" (42%). The mean ODI total score was 43.4% (SD 16.5%), the mean NDI total score was 28.3% (SD 17.4%), and the average severity of back pain was 59.5 (SD 26.9) points. The estimates at different time points are shown in Additional file 3. The trajectories of changes in back and leg pain followed similar patterns (Additional file 4). Thus, it could be assumed that further analyses describing changes in back pain equally described leg pain as well.

Changes in back and neck pain

By examining the trajectories of simultaneous changes in back and neck pain after surgery, two groups were identified (Fig. 1). The first, significantly larger group (82%)

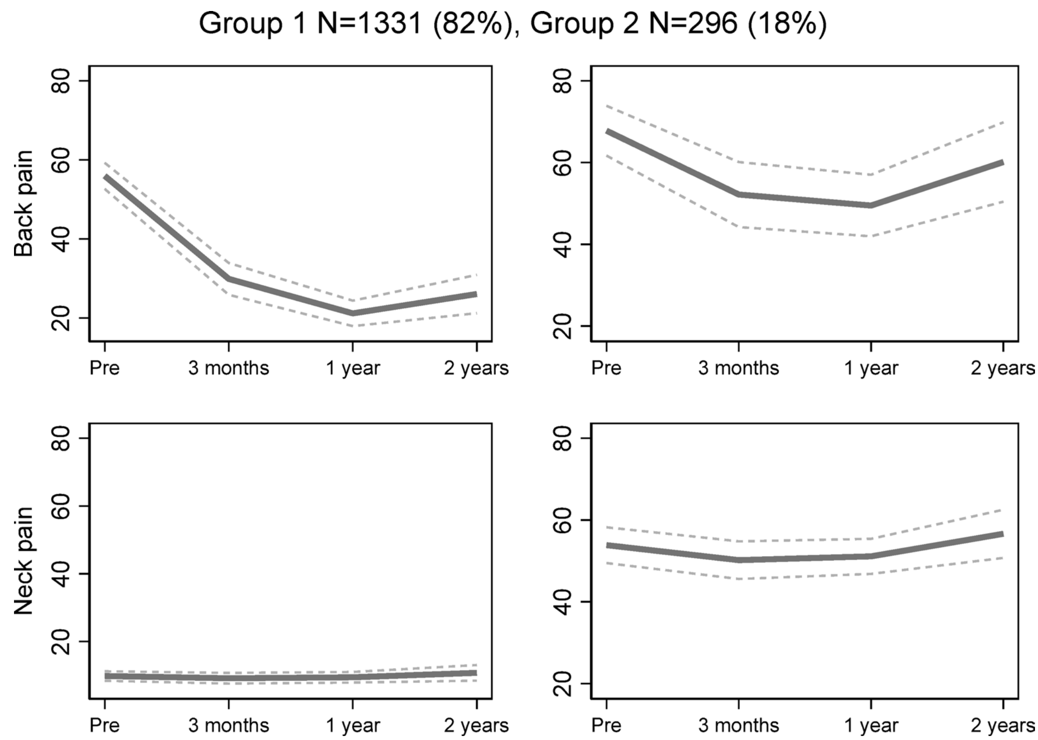

Fig. 1 Concurrent changes in back and neck pain. 95% confidence intervals are shown as dot lines

included those patients who experienced moderate back pain (55.9, 95% CI 52.6–59.2 points) and virtually no neck pain (9.8, 95% CI 8.4–11.2 points) before surgery. Among them, back pain quickly eased after the surgery and remained mild throughout the follow-up. Respectively, neck pain remained mild throughout the follow-up. The second, smaller group (18%) consisted of patients who experienced moderate back pain (67.8, 95% CI 61.7–73.9 points) and moderate neck pain (53.9, 95% CI 49.5–58.2 points) before surgery. Except for a slight decrease right after the surgery, both back and neck pain remained practically at the same level throughout the follow-up. Female sex (RRR 1.54, 95% CI 1.19–1.99), older age (RRR 1.30, 95% CI 1.01–1.68), and longer duration of preoperative pain (RRR 1.51, 95% CI 1.17–1.96) predicted higher probability of being classified to the second group with worse outcome (Table 3).

Changes in disability due to back pain and neck pain

Figure 2 shows the trajectories of simultaneous changes in disability due to either back or neck pain. In this analysis, three groups were identified. The largest group (56%) included patients who experienced moderate functional limitations due to back pain (32.7%, 95% CI 31.0–34.4%) and minimal limitations due to neck pain (15.7%, 95% CI 13.6–17.9%). Disability was improving for both forms of disability throughout the follow-up. The second group (33%) included patients who experienced severe disability due to back pain (48.4%, 95% CI 46.3–50.5%) and moderate limitations due to neck pain (36.4%, 95% CI 34.0–38.7%) before surgery. Both forms of disability rapidly improved immediately after surgery, but slightly worsened after one year of follow-up. Despite this worsening at the end of the follow-up, the final situation in terms of disability was still better at the end of the follow-up compared to the baseline. A small third group (11%) included those patients who were classified as housebound due to back pain (64.9%, 95% CI 61.3–68.5%) and experienced severe functional limitations due to neck pain (56.7%, 95% CI 53.8–59.6%). Only a slight change for the better was seen for disability caused by back pain, but not for disability caused by neck pain. The higher probability of being classified to the third group with the worst outcome was associated with a longer duration of preoperative pain (RRR 1.54, 95% CI 1.11–2.15) and higher BMI (RRR 1.44, 95% CI 1.04–1.98) (Table 3). Higher BMI was also predictive for probability of being classified to the second group characterized by improvement after surgery but slow deterioration after one year (RRR 1.36, 95% CI 1.09–1.68).

Descriptive characteristics and changes in pain after surgery by sex, age and preoperative pain duration

A sensitivity analysis was performed comparing the initial situation and the surgical methods used amongst older vs. younger patients, men vs. women, and patients

Table 3 Relative risk ratios (RRRs) adjusted for age and gender of being classified to a certain trajectory group

Factors and groups	RRR	95% CI	
Back pain & Neck pain			
Women vs. men			
Group 1	1.00	1.00	1.00
Group 2	**1.54**	**1.19**	**1.99**
Age (older vs. younger)			
Group 1	1.00	1.00	1.00
Group 2	**1.30**	**1.01**	**1.68**
Pain duration > = 3 months vs. <3 months			
Group 1	1.00	1.00	1.00
Group 2	**1.51**	**1.17**	**1.96**
BMI [a] ≥30 vs. BMI < 30			
Group 1	1.00	1.00	1.00
Group 2	1.27	0.98	1.63
Disability caused by back pain & Disability caused by neck pain			
Women vs. men			
Group 1	1.00	1.00	1.00
Group 2	1.13	0.92	1.41
Group 3	1.32	0.95	1.82
Age (older vs. younger)			
Group 1	1.00	1.00	1.00
Group 2	**0.76**	**0.62**	**0.95**
Group 3	0.84	0.61	1.15
Pain duration > = 3 months vs. <3 months			
Group 1	1.00	1.00	1.00
Group 2	1.07	0.86	1.32
Group 3	**1.54**	**1.11**	**2.15**
BMI ≥ 30 vs. BMI < 30			
Group 1	1.00	1.00	1.00
Group 2	**1.36**	**1.09**	**1.68**
Group 3	**1.44**	**1.04**	**1.98**

Statistically significant estimates are shown in bold

with longer vs. shorter duration of preoperative back pain (Additional file 5). The older patients were diagnosed more often with "M48 Spondylopathies" than the younger patients (60% vs. 14%), who instead had the main diagnosis of "M51 intervertebral disc disorders" more frequently than older counterparts (61% vs. 16%). Respectively, microsurgical excision of lumbar intervertebral disc displacement has been used more often in younger patients (49% vs. 10%), while decompression techniques have been more frequently used in older patients (26% vs. 12% for "ABC36" and 28% vs. 5% for "ABC56"). While there were some statistically significant differences based on sex, the estimated absolute numbers were similar for both sexes. The patients who have experienced longer preoperative pain were more likely to have main diagnosis of "M48 Spondylopathies" (52% vs. 32%) on contrary to the patients with shorter duration of preoperative pain who have a diagnosis of ""M51 intervertebral disc disorders" more often (50% vs. 18%). Respectively, microsurgical excision of lumbar intervertebral disc displacement has been used more often in the patients with shorter preoperative pain (49% vs 10%), decompression and fusion techniques have been more frequently used in patients with prolonged preoperative pain (23% vs. 15% for "ABC56" and 27% vs 12% for "NAG62"). However, the trajectories of concurrent changes in neck and back pain were similar for all three grouping variables (Additional file 6).

Discussion

This registry-based study among 1627 patients undergoing lumbar spine surgery investigated trajectories of concurrent changes in back and neck pain and changes in disability caused by either back or neck pain. Most of the patients experienced an improvement in disability after surgery, even though for most of them, disability slightly worsened after one year after surgery. Less than 20% of the patients reported substantial pain in the neck region. In this group, back pain was also moderate and pain in both regions did not change significantly during the follow-up. About half of the patients reported disability caused by neck pain. A small group of patients reported severe disability caused by both back pain and neck pain with only slight improvement in disability caused by back pain but not in disability caused by neck pain. The probability of belonging to the groups where no significant benefit was obtained from the surgery was increased by female sex, older age, overweight, and longer lasting preoperative pain.

The interconnection between problems in the neck and back regions can be assumed to exist as it has been previously reported that neck pain often occurs simultaneously with lower back pain [21]. A few previous studies have reported concurrent changes in back and neck pain in patients undergoing lumbar spinal surgery. In 2021, Cao et al. reported that both the disability caused by back and neck pain improved simultaneously after surgery for lumbar tandem stenosis [28]. In the present study, only a small proportion of the patients experienced significant neck pain while almost half of them reported moderate or severe scores of the NDI. This disproportion can probably be explained by the fact that the NDI has been derived from the ODI and several items may overlap [52]. This suggests that, among patients with back pain and disability caused by that pain, the NDI may describe functional limitation related to back pain and not to neck pain itself.

In this study, leg and back pain were found to improve similarly. This simultaneity has been observed in previous studies. For example, in 2020, Carrasco et al. reported that back pain was also relieved in the majority of patients undergoing lumbar spine decompression surgery [15]. The exact reasons for the effect of surgery, which is primarily intended to alleviate radiating leg pain,

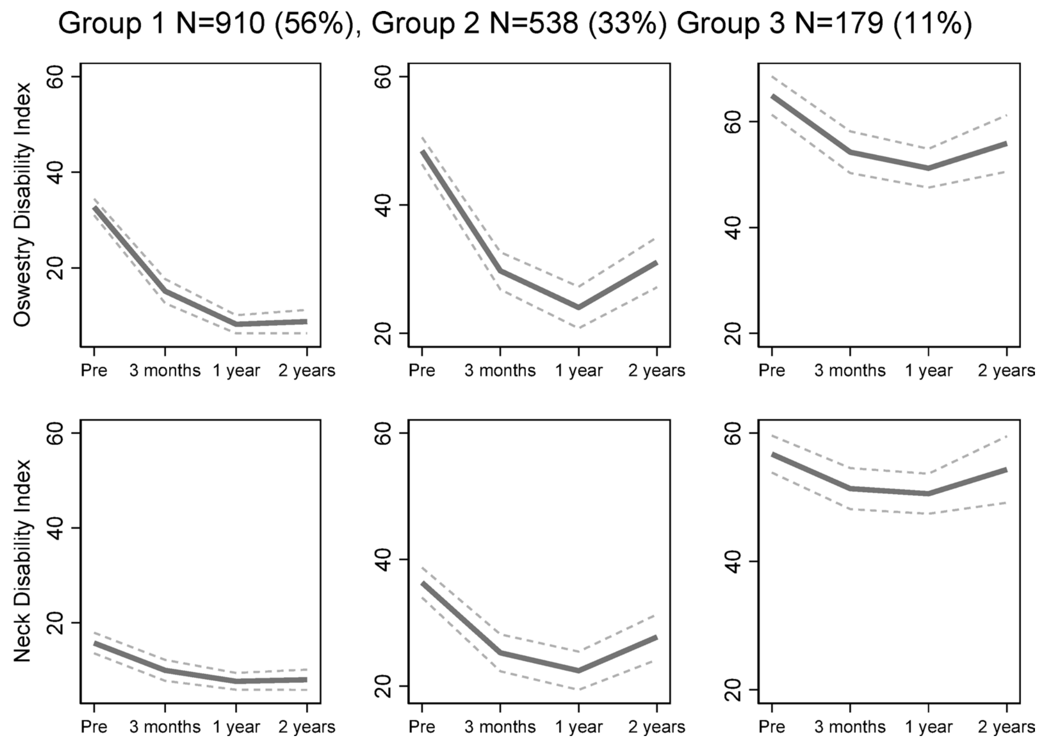

Fig. 2 Concurrent changes in disability measured by Oswestry Disability Index and Neck Disability Index. 95% confidence intervals are shown as dot lines

on local back pain are uncertain. One speculation could be that possible local inflammation is relieved when the existing compression of the area in the lumbar region is relieved, which leads to the reduction of also local back pain [53].

A weak correlation between pain and general functioning level, observed in the present study, has been noticed in many previous publications [54, 55]. Although the weakness of this correlation may seem paradoxical, the phenomenon is actually logical and corresponds to the current biopsychosocial model of functioning and disability, which is best described in the ICF classification. Although pain is undoubtedly an important function of the body, it is only one function among many other factors that determine overall functioning.

A few previous studies have found no correlation between obesity and the results of surgery in terms of pain, or disability [10, 11], which was not the case in the current study, as BMI > 30 kg/m^2 was associated with more pain and worse disability after surgery. However, these two previous studies were carried out with significantly smaller samples than this study, which could be the reason for the difference in the results. Previous studies have suggested that obesity is connected to chronic pain [56]. In 2020, Park et al. have studied a sample of almost 32,000 patients undergoing surgery on the lumbar spine and reported that a BMI of 30 kg/m^2 was the cut-off for worsening disability [9]. One explanation could be that, among obese persons, the pain has become chronic and therefore the surgery did not result in the desired response.

In the current study, female sex was associated with a higher probability of being classified to groups with worse outcomes. Yet, Nolte et al. reported that the pain visual analogue scale and the disability caused by back pain of both sexes improved similarly [3]. However, their results could be affected by the small sample size. Also, Triebel et al. reported that women improved similarly to men after lumbar fusion surgery [4]. However, although both sexes have benefited from surgery, the women had higher pain level and worse disability preoperatively and throughout the follow-up. Otherwise, similarly to the current results, the female sex has been previously associated with more severe disability and pain [2].

Longer preoperative pain duration and older age have also been associated with a worse surgical outcome in previous studies [5, 6]. On contrary, a retrospective review by Claus et al. reported that age was not independently associated with worse surgical outcome in patients undergoing multilevel transforaminal interbody lumbar fusion [7]. The discrepancy could be explained by the differences in age distributions as the respondents in the current study were significantly younger.

Older patients might potentially receive more extensive surgeries e.g., due to a higher prevalence of degenerative deformities including cervical spine level. Shorter symptom duration may commonly be indicative of disc herniations that usually have favorable outcomes during the natural course of the disease. It can be assumed that younger patients and patients with shorter duration of preoperative pain could differ from their counterparts by the reasons for surgery as well as for surgical techniques used. Indeed, some differences were seen: these patient groups were more likely to have a main diagnosis of "M51", which is commonly used to describe intervertebral disk disorders, while older patients were more often diagnosed with "M48", which is frequently used to describe spinal stenosis. Respectively, microsurgical excision of lumbar intervertebral disc displacement was more frequently used in younger patients and those with shorter duration of preoperative pain. In turn, older patients and those with prolonged preoperative pain were more prone to undergo fusion or decompression surgery. Despite these differences, the trajectories of concurrent changes in back and neck pain were invariant being similar for age, sex and the duration of preoperative pain.

The strengths of this study were a large sample size and repeated measures design. Some factors could limit the generalizability of the findings. A retrospective register-based study may suffer from possible significant confounders as well as from information and selection biases [57]. The study included heterogenic surgical techniques and reasons for surgery. Only a few descriptive variables were available. E.g., comorbidity could play a significant role in defining pain and disability. Due to the register-based retrospective design, missing data were not available for the analysis. The reasons for non-responding or potential differences between the respondents and non-respondents remained unknown. A large proportion of patients did not attend follow-up visits. It is possible that patients who had a poor outcome from surgery may have skipped follow-up visits due to dissatisfaction. However, it is equally possible that patients who had a particularly good outcome did not feel that follow-up visits were necessary. Missing data may significantly affect the accuracy of the estimated change in PROM scores in clinical registry data [58]. However, based on recent studies, non-respondents often correspond well to the entire population, and in this case, missing data would not really hinder the interpretation of the results [59, 60]. It has to be taken into account that the method of group-based trajectory analysis tries to utilize all the available information. This method uses all available responses even when the patient has answered only once or twice. For example, this statistical method cannot determine the rate of follow-up based on whether the respondent belongs to a certain trajectory group. Missing information on the rate of follow-up within this group of patients can certainly affect the reliability of the results and the ability to answer the main research question. In this situation, it is worth remembering that the results of the group-based trajectory analysis can only be interpreted as a trend. Before anything precise can be said about the situation in the studied population, the results must be verified through a large, preferably multicenter, prospective follow-up study.

Additional studies in different settings and populations are needed to investigate the interconnection between back and neck pain after surgery. This should include different surgery techniques and diverse spinal disorders. As well, the respective research can be made in non-surgical or even in general populations. Multigroup trajectory analysis can be of use for that aim. It would also be interesting to see if disability measured by NDI and ODI follow similar trajectories in the longer periods of follow-up. Due to the overlapping of items included in both the NDI and the ODI, it can be worth to investigate the concurrent changes in disability caused by back and neck pain using scales that are different from the ODI. Examining the respective interconnection between back and neck pain after cervical surgery could also be of interest.

Conclusion

For the majority of the patients, neck pain was not a major problem. On the other hand, disability due to neck pain was common. It is possible that the decrease in functional capacity that was seen in this study based on the NDI questionnaire in patients with back pain actually partly reflected a disability due to back pain. This possibility may question the validity of the NDI measure in people with back pain. In any case, it seems that post-operative changes in neck and back pain and the injury caused by either of them may be related and should be considered at least in some patient groups. Most patients experienced relief of pain and disability after surgery. Patients who were very painful and severely disabled before surgery formed the groups with no or very little improvement. Female gender, older age, longer duration of preoperative pain, and higher BMI were associated with a higher likelihood of being in the groups with worse outcome.

Abbreviations

GBTA	Group-based trajectory analysis
ODI	Oswestry Disability Index
NDI	Neck Disability Index
NCSP	Nordic classification of surgical procedures
BIC	Bayesian information criterion
AIC	Akaike information criterion
APP	Average posterior probability
RRR	Relative risk ratio

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-025-06377-9.

Supplementary Material 1: The logic behind the determining the number of clusters.

Supplementary Material 2: Goodness of fit of group-based trajectory analysis models.

Supplementary Material 3: Disability and pain scores at different waves by trajectory groups.

Supplementary Material 4: Concurrent changes in back pain and leg pain.

Supplementary Material 5: Descriptive characteristics of the sample by age, sex and preoperative pain duration.

Supplementary Material 6: Trajectories of back and neck pain by age, sex and preoperative pain duration.

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Author contributions
All the authors, KK, RL, JA, KP, and MS, have significantly contributed to the conception and design of the project, as well as the analysis and interpretation of data. KK was in charge of drafting the manuscript, while RL, JA, KP and MS critically revised it. Finally, all authors, have approved the version intended for publication. KK, RL, JA, KP and MS commit to being accountable for all aspects of the project, ensuring that any queries concerning the accuracy or integrity of the work are thoroughly investigated and addressed.

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Data availability
The dataset supporting the conclusions of this article is available upon reasonable request to Mikhail Saltychev.

Declarations

Ethics approval and consent to participate
All the methods were carried out in accordance with the Declaration of Helsinki. Given the retrospective nature of the register-based study, the need for informed consent or ethics approval was waived by the Ethics Committee of the wellbeing services county of Southwest Finland. The Ethics Committee of the wellbeing services county of Southwest Finland works under the wellbeing services county of Southwest Finland and covers all the expert responsibility area of Western Finland.

Consent for publication
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Competing interests
The authors declare no competing interests.

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References

1. Jacob KC, Patel MR, Parsons AW, Vanjani NN, Pawlowski H, Prabhu MC, et al. The effect of the severity of preoperative back pain on patient-reported outcomes, recovery ratios, and patient satisfaction following minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF). World Neurosurg. 2021;156:e254–65.
2. MacLean MA, Touchette CJ, Han JH, Christie SD, Pickett GE. Gender differences in the surgical management of lumbar degenerative disease: a scoping review. J Neurosurg Spine SPI. 2020;32(6):799–816.
3. Nolte MT, Jenkins NW, Parrish JM, Mohan S, Geoghegan CE, Jadczak CN, et al. The influence of sex on clinical outcomes in minimally invasive lumbar decompression. Int J Spine Surg. 2021;15(4):763–9.
4. Triebel J, Snellman G, Sandén B, Strömqvist F, Robinson Y. Women do not fare worse than men after lumbar fusion surgery: two-year follow-up results from 4,780 prospectively collected patients in the Swedish National spine register with lumbar degenerative disc disease and chronic low back pain. Spine J. 2017;17(5):656–62.
5. Alhaug OK, Dolatowski FC, Solberg TK, Lønne G. Predictors for failure after surgery for lumbar spinal stenosis: a prospective observational study. Spine J. 2023;23(2):261–70.
6. Aalto T, Sinikallio S, Kröger H, Viinamäki H, Herno A, Leinonen V, et al. Preoperative predictors for good postoperative satisfaction and functional outcome in lumbar spinal stenosis surgery: a prospective observational study with a two-year follow-up. Scand J Surg. 2012;101(4):255–60.
7. Claus CF, Tong D, Lytle E, Bahoura M, Garmo L, Li C, et al. Age as a predictor for complications and patient-reported outcomes in multilevel transforaminal lumbar interbody fusions: analyses from the Michigan spine surgery improvement collaborative (MSSIC). Spine. 2021;46(6):356–65.
8. Giannadakis C, Solheim O, Jakola AS, Nordseth T, Gulati AM, Nerland US, et al. Surgery for lumbar spinal stenosis in individuals aged 80 and older: a multicenter observational study. J Am Geriatr Soc. 2016;64(10):2011–8.
9. Park C, Garcia AN, Cook C, Shaffrey CI, Gottfried ON. Long-term impact of obesity on patient-reported outcomes and patient satisfaction after lumbar spine surgery: an observational study. J Neurosurg Spine. 2020;34(1):73–82.
10. Divi SN, Goyal DKC, Stull JD, Kothari P, Padua FG, Patel PD, et al. BMI does not affect complications or patient reported outcomes after lumbar decompression surgery. Clin Spine Surg. 2020;33(10):E579–85.
11. Rihn JA, Radcliff K, Hilibrand AS, Anderson DT, Zhao W, Lurie J, et al. Does obesity affect outcomes of treatment for lumbar stenosis and degenerative spondylolisthesis? Analysis of the spine patient outcomes research trial (SPORT). Spine (Phila Pa 1976). 2012;37(23):1933–46.
12. Skolasky RL, Wegener ST, Maggard AM, Riley LHI. The impact of reduction of pain after lumbar spine surgery: the relationship between changes in pain and physical function and disability. Spine. 2014;39(17):1426–32.
13. Phillips FM, Slosar PJ, Youssef JA, Andersson G, Papatheofanis F. Lumbar spine fusion for chronic low back pain due to degenerative disc disease: a systematic review. Spine. 2013;38(7):E409–22.
14. Hebert J, Bigney E, Wedderkopp N, Richardson EA, Darling MA, Manson NA. 179. Predictors of clinical outcome following surgery for lumbar spinal stenosis: a study of postoperative pain and disability trajectories. Spine J. 2019;19(9, Supplement):S86-S7.
15. Carrasco R, Elmalky M, Sabou S, Leach J, Verma R, Mohammad S, et al. Concomitant back and leg pain as predictors for trajectories of poor outcome after single level lumbar micro-decompression alone and with micro-discectomy: a study of 3,308 patients. J Spine Surg. 2020;6(4):688–702.
16. Wang S, Hebert JJ, Abraham E, Vandewint A, Bigney E, Richardson E, et al. Postoperative recovery patterns following discectomy surgery in patients with lumbar radiculopathy. Sci Rep. 2022;12(1):11146.
17. Halicka M, Duarte R, Catherall S, Maden M, Coetsee M, Wilby M, et al. Predictors of pain and disability outcomes following spinal surgery for chronic low back and radicular pain: a systematic review. Clin J Pain. 2022;38(5):368–80.
18. Oh CH, Yoon SH. Whole spine disc degeneration survey according to the ages and sex using Pfirrmann disc degeneration grades. Korean J Spine. 2017;14(4):148–54.
19. Teraguchi M, Yoshimura N, Hashizume H, Muraki S, Yamada H, Minamide A, et al. Prevalence and distribution of intervertebral disc degeneration over the entire spine in a population-based cohort: the Wakayama spine study. Osteoarthr Cartil. 2014;22(1):104–10.
20. Fernandez-de-las-Penas C, Hernandez-Barrera V, Alonso-Blanco C, Palacios-Cena D, Carrasco-Garrido P, Jimenez-Sanchez S, et al. Prevalence of neck and low back pain in community-dwelling adults in spain: a population-based National study. Spine (Phila Pa 1976). 2011;36(3):E213–9.
21. Yabe Y, Hagiwara Y, Sugawara Y, Tsuji I. Association between low back pain and neck pain: a 3-year longitudinal study using the data of the people after the great East Japan earthquake. Tohoku J Exp Med. 2023;261(1):43–9.
22. Leboeuf-Yde C, Fejer R, Nielsen J, Kyvik KO, Hartvigsen J. Pain in the three spinal regions: the same disorder? Data from a population-based sample of 34,902 Danish adults. Chiropr Man Ther. 2012;20:11.
23. Hagen EM, Svensen E, Eriksen HR, Ihlebæk CM, Ursin H. Comorbid subjective health complaints in low back pain. Spine. 2006;31(13):1491–5.
24. Alvin MD, Alentado VJ, Lubelski D, Benzel EC, Mroz TE. Cervical spine surgery for tandem spinal stenosis: the impact on low back pain. Clin Neurol Neurosurg. 2018;166:50–3.
25. Epstein NE, Epstein JA, Carras R, Murthy VS, Hyman RA. Coexisting cervical and lumbar spinal stenosis: diagnosis and management. Neurosurgery. 1984;15(4).

26. Felbaum DR, Fayed I, Stewart JJ, Sandhu FA. Relief of lumbar symptoms after cervical decompression in patients with tandem spinal stenosis presenting with primarily lumbar pain. Cureus. 2016;8(12):e940.
27. Pennington Z, Alentado VJ, Lubelski D, Alvin MD, Levin JM, Benzel EC, et al. Quality of life changes after lumbar decompression in patients with tandem spinal stenosis. Clin Neurol Neurosurg. 2019;184:105455.
28. Cao J, Gao X, Yang Y, Lei T, Shen Y, Wang L, et al. Simultaneous or staged operation for tandem spinal stenosis: surgical strategy and efficacy comparison. J Orthop Surg Res. 2021;16(1):214.
29. Baroncini A, Maffulli N, Schafer L, Manocchio N, Bossa M, Foti C, et al. Physiotherapeutic and non-conventional approaches in patients with chronic low-back pain: a level I bayesian network meta-analysis. Sci Rep. 2024;14(1):11546.
30. Miranda L, Quaranta M, Oliva F, Maffulli N. Stem cells and discogenic back pain. Br Med Bull. 2023;146(1):73–87.
31. Migliorini F, Vaishya R, Pappalardo G, Schneider M, Bell A, Maffulli N. Between guidelines and clinical trials: evidence-based advice on the pharmacological management of non-specific chronic low back pain. BMC Musculoskelet Disord. 2023;24(1):432.
32. Baroncini A, Maffulli N, Al-Zyoud H, Bell A, Sevic A, Migliorini F. Nonopioid pharmacological management of acute low back pain: a level I of evidence systematic review. J Orthop Res. 2023;41(8):1781–91.
33. Baroncini A, Maffulli N, Eschweiler J, Molsberger F, Klimuch A, Migliorini F. Acupuncture in chronic aspecific low back pain: a Bayesian network meta-analysis. J Orthop Surg Res. 2022;17(1):319.
34. Migliorini F, Maffulli N, Eschweiler J, Tingart M, Baroncini A. Non-steroidal anti-inflammatory drugs and gabapentinoids for chronic lumbar pain: a Bayesian network meta-analysis of randomized controlled trials. Br Med Bull. 2021;138(1):85–95.
35. Migliorini F, Maffulli N, Eschweiler J, Betsch M, Catalano G, Driessen A, et al. The Pharmacological management of chronic lower back pain. Expert Opin Pharmacother. 2021;22(1):109–19.
36. Giordano L, Murrell WD, Maffulli N. Prolotherapy for chronic low back pain: a review of literature. Br Med Bull. 2021;138(1):96–111.
37. Baroncini A, Maffulli N, Eschweiler J, Knobe M, Tingart M, Migliorini F. Management of facet joints osteoarthritis associated with chronic low back pain: a systematic review. Surgeon. 2021;19(6):e512–8.
38. Yana M, Güneş M, Şimşek A, Apaydın AS, Akıncı C, Özmen T. The effect of Graston technique on pain, proprioception, flexibility, and disability in patients with chronic non-specific low back pain. Altern Ther Health Med. 2024;30(4):24–30.
39. Apaydin AS, Bozyiğit B, Koç-Apaydin Z, Güneş M, Yana M. Effects of different surgical treatments on pain, disability, anxiety and quality of life in lumbar disc herniation. Cir Cir. 2024;92(1):39–45.
40. Baroncini A, Maffulli N, Pilone M, Pipino G, Memminger MK, Pappalardo G, et al. Prognostic factors in patients undergoing physiotherapy for chronic low back pain: a level I systematic review. J Clin Med. 2024;13:22.
41. Apaydin AS, Güneş M, Yana M. Investigation of functional disability, pain, and quality of life in patients with cervical radiculopathy by gender. Med Records. 2024;6(1):14–9.
42. Apaydin AS, Güneş M. Relationships between stenosis severity, functional limitation, pain, and quality of life in patients with cervical spondylotic radiculopathy. Turk J Med Sci. 2024;54(4):727–34.
43. Apaydın ZK, Demir N, Apaydin AS. The relationship between pain Intensity, pain beliefs, and emotion regulation skills in non-surgical spinal pathology pain. Med Records. 2024;6(2):2249–254.
44. Ferat M, Apaydin AS. Investigation of functional disability, depression and quality of life according to pain intensity in patients with cervical radiculopathy. Med Sci | Int Med J. 2025;4:891–6.
45. Migliorini F, Maffulli N. Choosing the appropriate pharmacotherapy for nonspecific chronic low back pain. J Orthop Surg Res. 2022;17(1):556.
46. Marjamaa J, Huttunen J, Kankare J, Malmivaara A, Pernaa K, Salmenkivi J, et al. The Finnish spine register (FinSpine): development, design, validation and utility. Eur Spine J. 2023;32(11):3731–43.
47. Vernon H, Mior S. The neck disability index: a study of reliability and validity. J Manip Physiol Ther. 1991;14(7):409–15.
48. Fairbank JC, Couper J, Davies JB, O'Brien JP. The Oswestry low back pain disability questionnaire. Physiotherapy. 1980;66(8):271–3.
49. Fairbank JC, Pynsent PB. The Oswestry disability index. Spine (Phila Pa 1976). 2000;25(22):2940–52. discussion 52.
50. Smeets R, Köke A, Lin C-W, Ferreira M, Demoulin C. Measures of function in low back pain/disorders: low back pain rating scale (LBPRS), Oswestry disability index (ODI), progressive isoinertial lifting evaluation (PILE), Quebec back pain disability scale (QBPDS), and Roland-Morris disability questionnaire (RDQ). Arthritis Care Res. 2011;63(S11):S158–73.
51. Jensen MP, Chen C, Brugger AM. Interpretation of visual analog scale ratings and change scores: a reanalysis of two clinical trials of postoperative pain. J Pain. 2003;4(7):407–14.
52. Spiegel MA, Lafage R, Lafage V, Ryan D, Marascalchi B, Trimba Y, et al. Developing the total disability index based on an analysis of the interrelationships and limitations of Oswestry and neck disability index. Spine (Phila Pa 1976). 2016;41(1):74–81.
53. Li W, Gong Y, Liu J, Guo Y, Tang H, Qin S, et al. Peripheral and central pathological mechanisms of chronic low back pain: a narrative review. J Pain Res. 2021;14:1483–94.
54. Andrews JS, Cenzer IS, Yelin E, Covinsky KE. Pain as a risk factor for disability or death. J Am Geriatr Soc. 2013;61(4):583–9.
55. DeVine J, Norvell DC, Ecker E, Fourney DR, Vaccaro A, Wang J, et al. Evaluating the correlation and responsiveness of patient-reported pain with function and quality-of-life outcomes after spine surgery. Spine (Phila Pa 1976). 2011;36(21 Suppl):S69–74.
56. Lucha-López MO, Hidalgo-García C, Monti-Ballano S, Márquez-Gonzalvo S, Ferrández-Laliena L, Müller-Thyssen-Uriarte J et al. Body Mass Index and Its Influence on Chronic Low Back Pain in the Spanish Population: A Secondary Analysis from the European Health Survey (2020). Biomedicines. 2023;11(8).
57. Muriel R-S. Limitations and biases in cohort studies. In: Barría RM, editor. Cohort studies in health sciences. Rijeka: IntechOpen; 2018. Ch. 3.
58. Ayilara OF, Zhang L, Sajobi TT, Sawatzky R, Bohm E, Lix LM. Impact of missing data on bias and precision when estimating change in patient-reported outcomes from a clinical registry. Health Qual Life Outcomes. 2019;17(1):106.
59. Klimko N, Danner N, Salo H, Malmivaara A, Leinonen V, Huttunen J. Outcome measures after anterior cervical decompression and fusion surgery -non-respondents do not bias the results: a Finnish spine register (FinSpine) study. Brain Spine. 2025;5:104179.
60. Ingebrigtsen T, Aune G, Karlsen ME, Gulati S, Kolstad F, Nygaard ØP, et al. Non-respondents do not bias outcome assessment after cervical spine surgery: a multicenter observational study from the Norwegian registry for spine surgery (NORspine). Acta Neurochir (Wien). 2023;165(1):125–33.