

# Adult Spinal Deformity Surgery Is Associated with Increased Productivity and Decreased Absenteeism From Work and School

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**Study Design.** Retrospective cohort study.

**Objective.** We hypothesized that adult spinal deformity (ASD) surgery would be associated with improved work- and school-related productivity, as well as decreased rates of absenteeism.

**Summary of Background Data.** ASD patients experience markedly decreased health-related quality of life along many dimensions.

**Methods.** Only patients eligible for 2-year follow-up were included, and those with a history of previous spinal fusion were excluded. The primary outcome measures in this study were Scoliosis Research Society-22r score (SRS-22r) questions 9 and 17. A repeated measures mixed linear regression was used to

analyze responses over time among patients managed operatively (OP) versus nonoperatively (NON-OP).

**Results.** In total, 1188 patients were analyzed. 66.6% were managed operatively. At baseline, the mean percentage of activity at work/school was 56.4% (SD 35.4%), and the mean days off from work/school over the past 90 days was 1.6 (SD 1.8). Patients undergoing ASD surgery exhibited an 18.1% absolute increase in work/school productivity at 2-year follow-up versus baseline ( $P < 0.0001$ ), while no significant change was observed for the nonoperative cohort ( $P > 0.5$ ). Similarly, the OP cohort experienced 1.1 fewer absent days over the past 90 days at 2 years versus baseline ( $P < 0.0001$ ), while the NON-OP cohort showed no such difference ( $P > 0.3$ ). These differences were largely preserved after stratifying by baseline employment status, age group, sagittal vertical axis (SVA), pelvic incidence minus lumbar lordosis (PI-LL), and deformity curve type.

**Conclusion.** ASD patients managed operatively exhibited an average increase in work/school productivity of 18.1% and decreased absenteeism of 1.1 per 90 days at 2-year follow-up, while patients managed nonoperatively did not exhibit change from baseline. Given the age distribution of patients in this study, these findings should be interpreted as pertaining primarily to obligations at work or within the home. Further study of the direct and indirect economic benefits of ASD surgery to patients is warranted.

**Key words:** absenteeism, adult spinal deformity, HRQOL, work productivity.

**Level of Evidence:** 3  
**Spine 2022;47:287–294**

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Acknowledgment date: April 22, 2021. First revision date: June 3, 2021. Acceptance date: October 4, 2021.

The manuscript submitted does not contain information about medical device(s)/drug(s).

No funds were received in support of this work.

Relevant financial activities outside the submitted work: board membership, consultancy, grants, royalties, employment, payment for lecture, travel/accommodations/meeting expenses.

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DOI: 10.1097/BRS.0000000000004271

Adult spinal deformity (ASD) has been found to have a devastating personal health impact on those afflicted as well as large societal and economic burdens.<sup>1–3</sup> Surgery for ASD has been repeatedly demonstrated to have a

positive impact on patient reported outcome measures assessing pain and disability as compared with nonoperatively managed patients.<sup>4–6</sup> However, the impact of surgical intervention on return-to-work capacity has yet to be elucidated.

Health Related Quality of Life data is commonly reported through the collection of several validated outcome measures including the Oswestry Disability Index (ODI), Short Form-36 version (SF-36), Visual Analog Scales (VAS), and Scoliosis Research Society-22r score (SRS-22r).<sup>7–11</sup> Questions pertaining to occupation-related functionality are included in the commonly utilized SRS-22r questionnaire, however, correlations between operative *versus* nonoperative intervention and productivity in this domain have not been made. Maintaining a capacity to complete career-related tasks can have implications for psychologic and financial well-being among ASD patients and clinicians should be able to provide evidence-based counseling.<sup>12</sup> We hypothesized that ASD surgery would be associated with improved work- and school-related productivity, as well as decreased rates of absenteeism.

## METHODS

### Data Sources

This study utilized a multicenter, prospectively collected adult spinal deformity database. The database included only patients more than or equal to 18 years old with adult degenerative or idiopathic scoliosis, and at least one of the following radiographic criteria: coronal Cobb angle more than or equal to 20°, sagittal vertical axis (SVA) more than or equal to 5 cm, pelvic tilt (PT) more than or equal to 25°, or thoracic kyphosis (TK) more than or equal to 60°. Those with a secondary cause of deformity, including traumatic, neuromuscular, congenital, infectious, and paralytic, were excluded. Patient consent was obtained, and institutional review board approval was obtained at each participating site.

### Patient Selection

Only patients eligible for 2-year follow-up were included. Patients with a history of previous spinal fusion were excluded.

### Dependent Variable

The primary dependent variables were components of the SRS-22r questionnaire, with responses recorded at baseline, 6 months, 1 year, and 2 years. Questions 9 (what is your current level of work/school activity? Answers 0%, 25%, 50%, 75%, 100%) and 17 (in the last 3 months have you taken any days off of work, including household work, or school because of back pain? 0 days, 1 day, 2 days, 3 days, 4+ days) were analyzed.

### Independent Variables

The primary independent variable in this study was operative *versus* nonoperative management. Analyses were further stratified by patient baseline employment status, age

group, as well as baseline Schwab modifier for SVA and pelvic incidence minus lumbar lordosis (PI-LL), and deformity curve type (thoracic, double, lumbar, sagittal, and mixed).

## Statistical Analysis

Descriptive statistics were generated. Follow-up data were transposed to a long format. Responses to SRS-22r questions 9 and 17 were considered both ordinal and interval. Repeated measures mixed linear regression was used to assess patient responses over time among patients managed operatively (OP) *versus* nonoperatively (NON-OP). Subanalyses by baseline employment status, patient age, baseline SVA, baseline PI-LL, and baseline deformity curve type were conducted.

## RESULTS

### Descriptive Statistics

In total, 1184 patients were included in this study. Most patients (66.7%,  $n=792$ ) were managed operatively (Table 1). The vast majority were female (78.9%,  $n=934$ ), and patients were relatively evenly distributed across age categories of less than 50 (27.6%,  $n=328$ ), 50 to 59 (21.1%,  $n=251$ ), 60 to 69 (30.1%,  $n=357$ ), and more than or equal to 70 (21.2%,  $n=252$ ). At baseline, 46.8% ( $n=530$ ) of patients were employed. The mean percent of normal work/school activity at baseline was 56.4% (SD 35.4%), and at 2-year follow-up was 67.3% (SD 34.0%) (Table 2). Mean days off work/school over the past 90 days at baseline was 1.63 (SD 1.79), and at 2-year follow-up was 0.90 (SD 1.49). At 2-year follow-up, patients managed nonoperatively had data for work percent and days of 50.0% and 49.7%, respectively, while patients managed operatively had data for 65.2% and 62.9%, respectively.

### Operative Versus Nonoperative Management

Patients managed operatively (OP) exhibited lower work/school activity at baseline *versus* those managed nonoperatively (NONOP) (46.3% *vs.* 75.8%,  $P<0.0001$ ), but activity among OP patients increased significantly at 2 years from baseline (+18.1%,  $P<0.0001$ ), as compared with no significant increase among NONOP patients (–1.2%,  $P=0.67$ ) (Figure 1). Similarly, while OP patients missed more days of work/school at baseline *versus* NONOP patients (1.99 *vs.* 0.95,  $P<0.0001$ ), OP patients exhibited significantly decreased absenteeism at 2 years *versus* baseline (–1.06,  $P<0.0001$ ) and NONOP patients did not (–0.14,  $P=0.33$ ) (Figure 2).

### Sub-Analyses

Among patients who were both employed and unemployed at baseline, OP patients exhibited significantly improved percent of normal school/work activity and days off school/work/home activities over the past 90 days at 2 years *versus* baseline, while NONOP patients exhibited no such differences. (Figures 3 and 4) Stratified by patient age category,

**TABLE 1. Descriptive Statistics (Categorical Variables)**

	N	%
All patients	1184	–
<b>Operative management</b>		
No	396	33.3
Yes	792	66.7
<b>Gender</b>		
Male	250	21.1
Female	934	78.9
Frequency missing = 4		
<b>Age</b>		
<50	328	27.6
50–59	251	21.1
60–69	357	30.1
≥70	252	21.2
<b>Baseline work status</b>		
Employed	530	46.8
Unemployed	602	53.2
Frequency missing = 56		
<b>Deformity type classification</b>		
D	132	18.2
L	132	18.2
M	235	32.3
S	198	27.2
T	30	4.1
Frequency missing = 461		
<b>UIV</b>		
C2	3	0.4
T1	4	0.5
T2	68	8.7
T3	90	11.5
T4	127	16.3
T5	16	2.1
T6	5	0.6
T7	2	0.3
T8	18	2.3
T9	41	5.3
T10	197	25.2
T11	75	9.6
T12	13	1.7
L1	18	2.3
L2	37	4.7
L3	37	4.7
L4	21	2.7
L5	9	1.2
Frequency missing = 11		
<b>LIV</b>		
T4	1	0.1
T11	1	0.1
T12	10	1.3
L1	19	2.4
L2	27	3.5
L3	38	4.9
L4	49	6.3
L5	62	7.9
S1	60	7.7
S2	24	3.1
Ilium	490	62.7
Frequency missing = 11		
<i>LIV, lower instrumented vertebrae; UIV, upper instrumented vertebrae</i>		

**TABLE 2. Descriptive Statistics (Continuous Variables)**

	Mean	SD	Missing
<b>SRS-22r Q9: percent work/school activity</b>			
Baseline	56.4%	35.4%	65
2 years follow-up	67.3%	34.0%	474
<b>SRS-22r Q17: days off school/work in past 90 days</b>			
Baseline	1.63	1.79	103
2 year follow-up	0.90	1.49	493
<b>Baseline alignment</b>			
SVA	40.2	62.5	9
T1PA	18.5	12.1	25
PI	54.5	12.7	16
PT	21.5	10.5	16
PI-LL	9.8	19.6	16
<b>2 years alignment</b>			
SVA	24.0	53.2	433
T1PA	16.1	10.9	434
PI	54.6	12.5	433
PT	20.3	10.3	433
PI-LL	2.9	15.7	433
<i>PI-LL indicates pelvic incidence minus lumbar lordosis; PT, pelvic tilt; SRS-22r, Scoliosis Research Society-22r score; SD, standard deviation; SVA, sagittal vertical axis.</i>			

OP patients exhibited significant improvements in percent of normal work/school activity at 2 years *versus* baseline among all groups (all  $P < 0.005$ ), while the NONOP cohort did not show any such differences (all  $P > 0.3$ ). (Figure 5) A similar observation was made for days off work/school/home activities over the past 90 days, where OP patients showed significant improvement at 2-year follow-up *versus* baseline among all age groups (all  $P < 0.0001$ ), whereas none of the NONOP groups exhibited such a difference (all  $P > 0.3$ ) (Figure 6). Among patients managed operatively, patients with Schwab modifiers for SVA and PI-LL of 0, +, and ++ all exhibited significant increases in percent of normal work/school activity (all  $P < 0.05$ ) and days off work/school/home activities over the past 90 days (all  $P < 0.05$ ) at 2-years *versus* baseline (Figures S1–S4, <http://links.lww.com/BRS/B813>, <http://links.lww.com/BRS/B814>, <http://links.lww.com/BRS/B815>, <http://links.lww.com/BRS/B816>). OP patients also exhibited significant improvements at 2 years from baseline in both outcome measures among double, lumbar, sagittal, and mixed deformity curve types (all  $P < 0.05$ ) though differences in the thoracic curve type (n = 30 patients) did not reach statistical significance ( $P > 0.05$ ). (Figures S5, S6, <http://links.lww.com/BRS/B817>, <http://links.lww.com/BRS/B818>).

**DISCUSSION**

In this retrospective cohort study, adult spinal deformity patients undergoing primary surgery exhibited increased percent activity at work/school and decreased days off work/school/home activities over the previous 90 days at 2-year follow-up *versus* baseline. Patients managed non-operatively did not exhibit any significant change in these

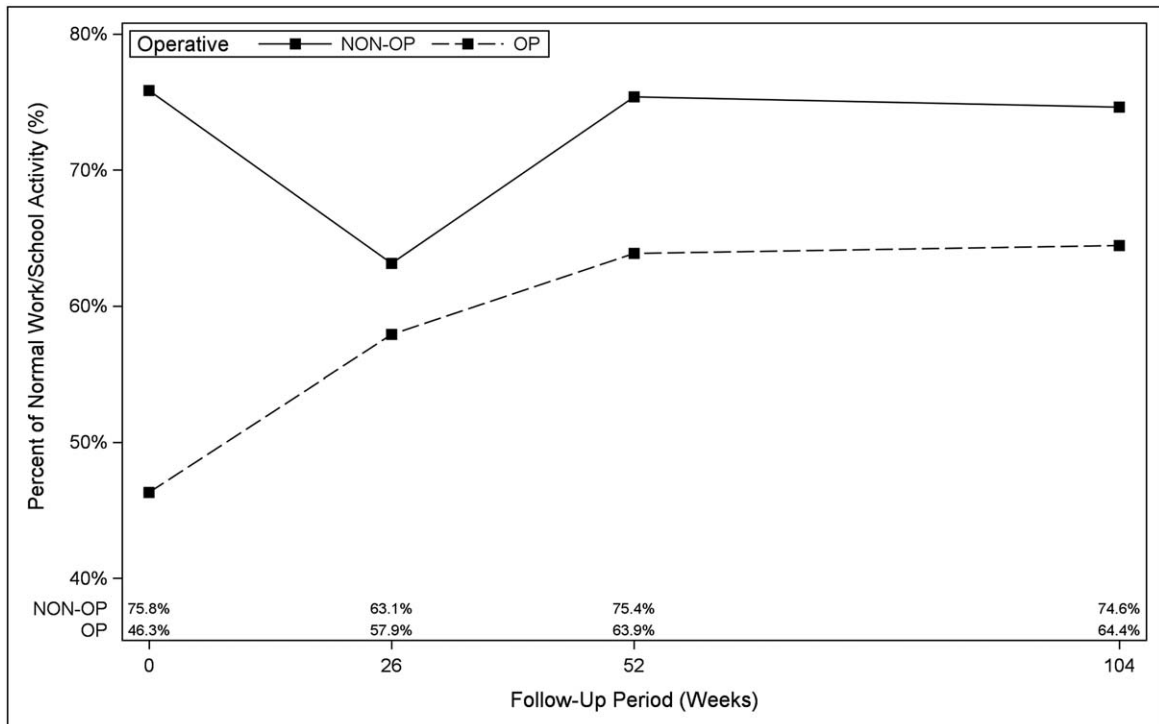


Figure 1. Percent of normal work/school activity, operative versus nonoperative.

metrics at 2-year follow-up. These observations were consistent across baseline employment status, age categories and, for those managed operatively, across Schwab modifiers for SVA and PI-LL, as well as deformity curve type.

Several previous studies have examined the cost-effectiveness of adult spinal deformity surgery. Neal *et al*<sup>13</sup> analyzed 31 patients and observed a mean annual change in quality adjusted life year (QALY) of 0.08, with an average

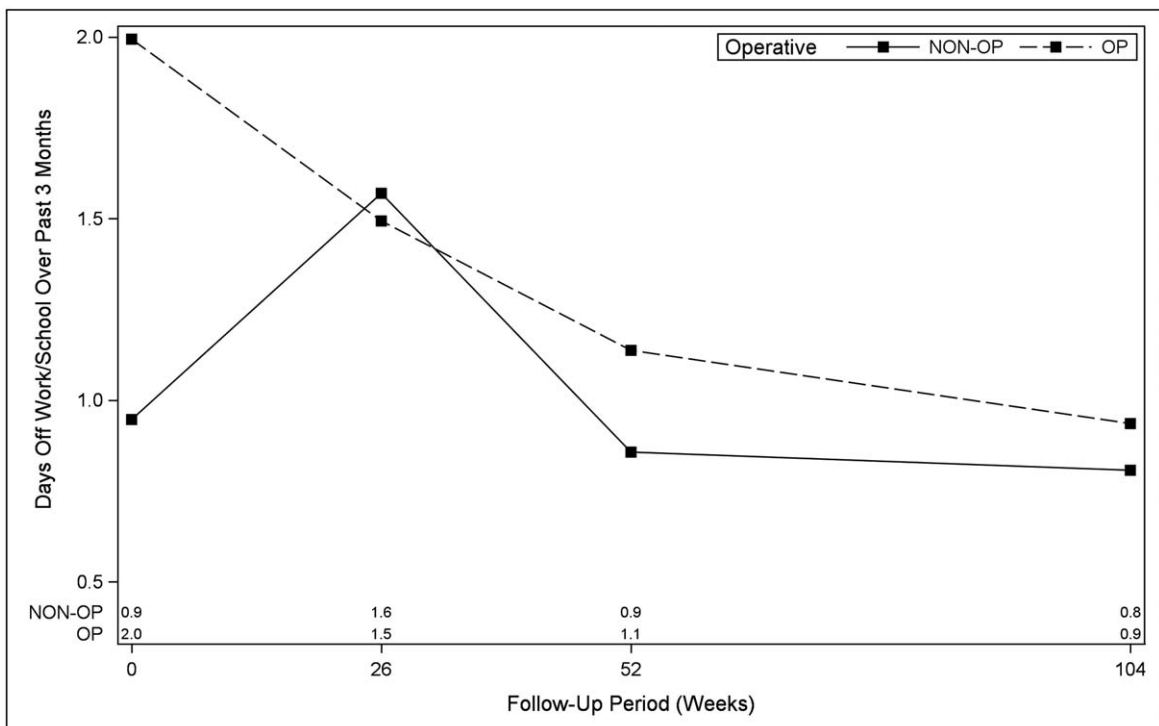


Figure 2. Days off work/school/home activities over the past 90 days, operative versus nonoperative.

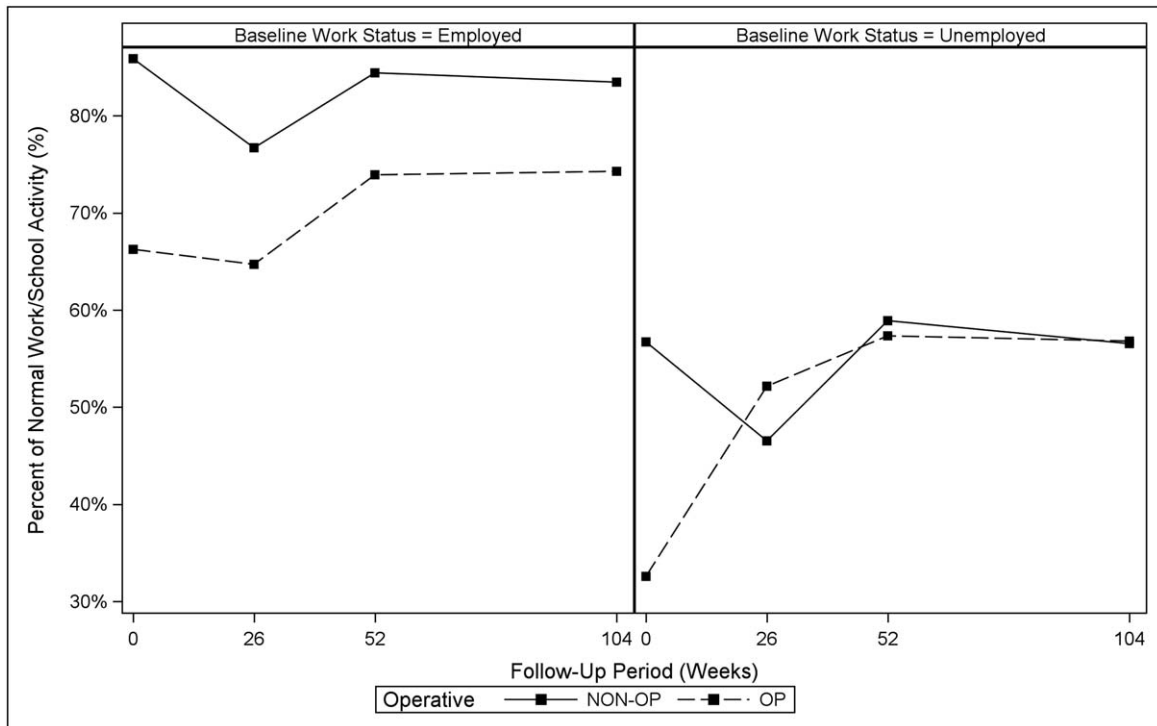


Figure 3. Percent of normal work/school activity, operative versus nonoperative, by baseline employment status.

cost of \$82,730.90. At 5 years postoperatively, 19% of patients met a \$100,000/QALY threshold, which increased to approximately half of patients by 10 years postoperatively. Terran *et al*<sup>1</sup> conducted a cost-effectiveness study of

541 adult spinal deformity patients, and similarly observed an increase of 0.07 to 0.08 QALY annually in patients undergoing surgery. With a threshold of \$100,000/QALY, 40.7% of surgeries were cost-effective at 5-year follow-up.

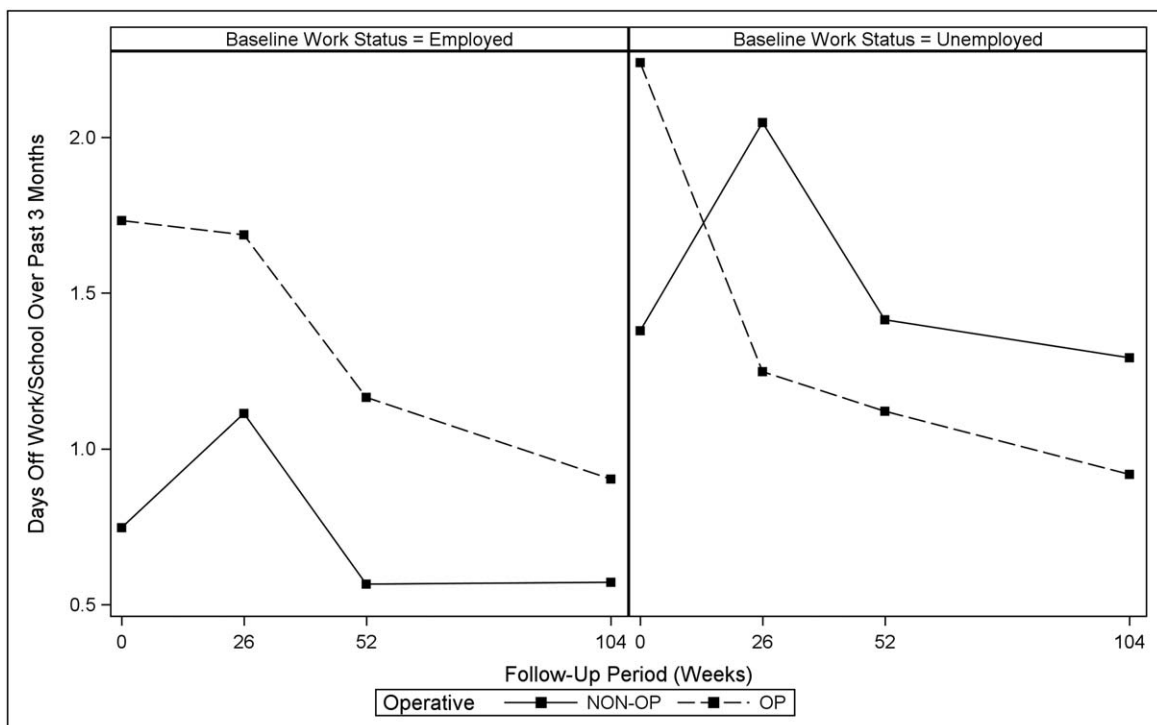


Figure 4. Days off work/school/home activities over the past 90 days, operative versus nonoperative, by baseline employment status.

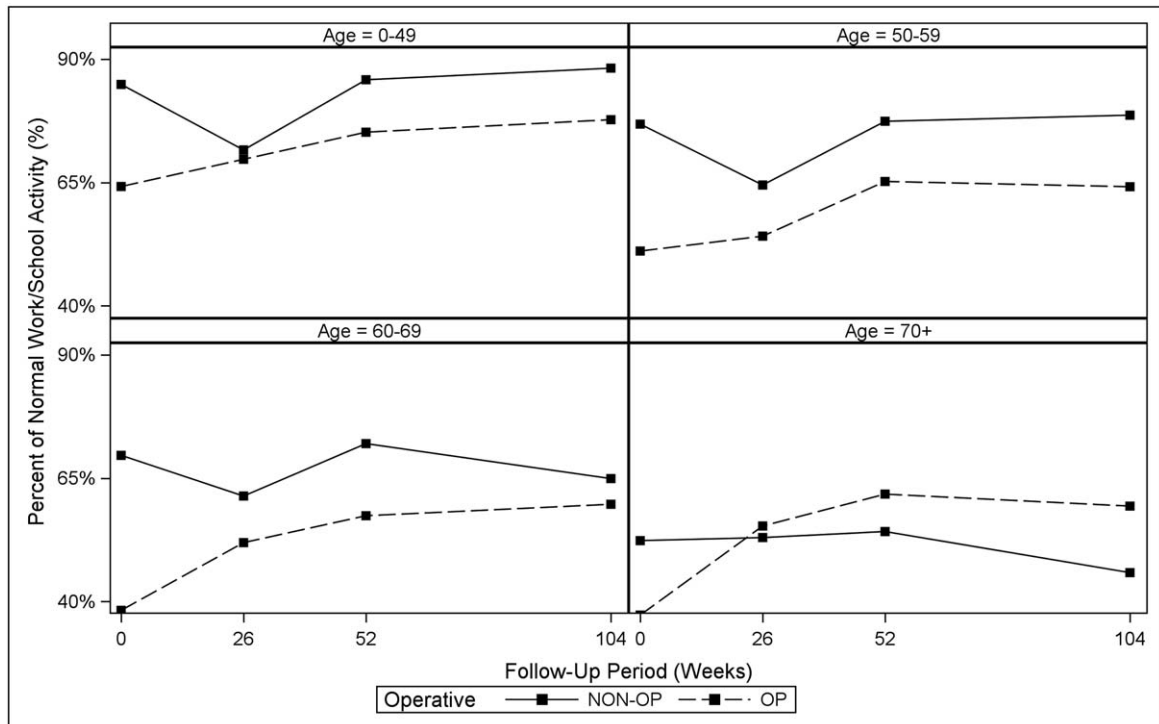


Figure 5. Percent of normal work/school activity, operative versus nonoperative, by age.

For comparison, Lavernia *et al*<sup>14</sup> found an annual increase in quality of well-year (QWY) of 0.08 for primary total hip arthroplasty (THA), and 0.06 for revision THA. Importantly, cost-effectiveness for these studies was determined as the ratio of the cost of an intervention to the projected

cumulative health benefit that a patient will derive over their post-intervention lifetime.

The key implication of the present study is that adult spinal deformity surgery may be associated with a direct increase in economic productivity via improved participation in the

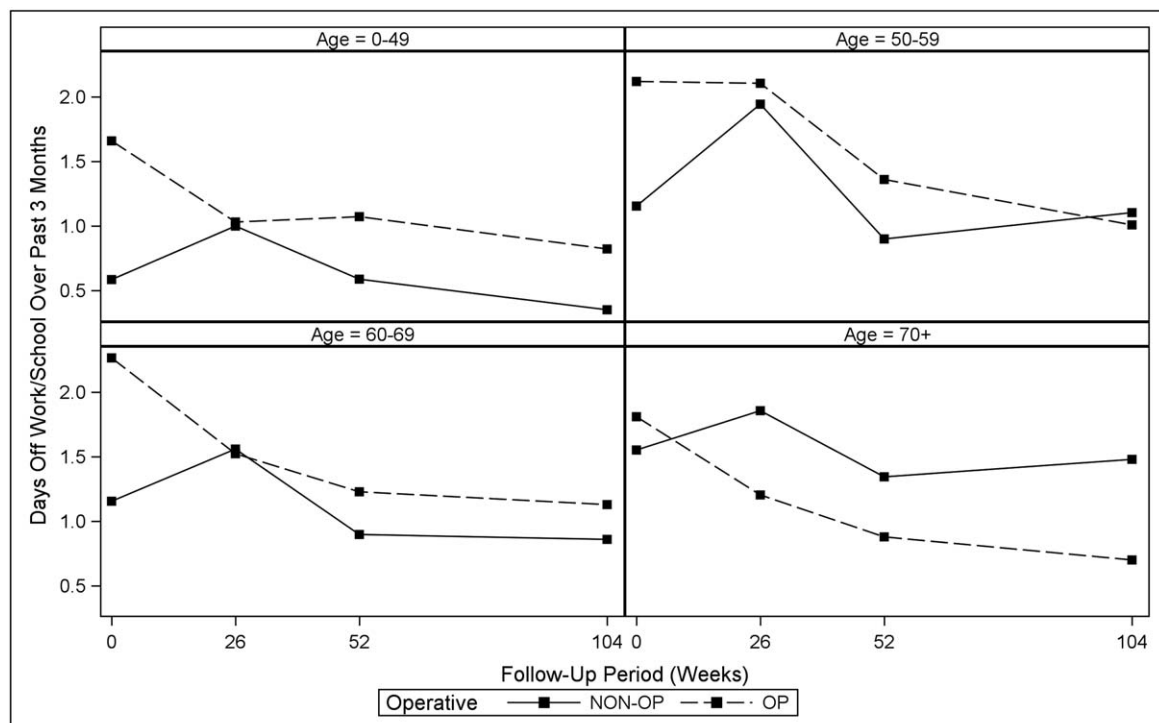


Figure 6. Days off work/school/home activities over the past 90 days, operative versus nonoperative, by age.

workforce and education. This suggests that the above literature may conservatively underestimate the economic benefit of ASD surgery, as procedural cost estimates do not account for offsets from increased productivity. Disability and absenteeism are complex in their manifestations and multifactorial in their origins. This study was designed neither to quantify the specific cost offset associated with ASD surgery nor to examine causes of disability and return to work among subpopulations. Both of these avenues merit pursuit, but remain beyond the scope of the present work. Rather, by taking a population-level view of adult spinal deformity patients, this investigation ultimately advocates for a more holistic evaluation of the benefits of ASD surgery. It is likely that increased productivity directly benefits patients, employers, and society. We hope that the present study will inspire future investigation of these dynamics.

Adult spinal deformity has substantial negative impact on patient HRQOL.<sup>15,16</sup> Previous studies have shown that operative management of adult spinal deformity is associated with increased HRQOL along a variety of dimensions.<sup>4,17–21</sup> This study showed that patients managed operatively exhibited increased productivity at 2-years post-operative follow-up. This study used questions 9 and 17 in the SRS-22r instrument. A 2019 study by Ames *et al*<sup>22</sup> developed predictive models for individual questions of the SRS-22r. Models for question 17 exhibited the highest area under the receiver operating characteristic curve (AUROC) as compared with models for the other SRS-22r questions. The authors noted that question 17, along with the other questions predicted with highest AUROC, were related to “pain, disability, and social and labor function.” In the context of the present study, these results suggest that any potential direct economic benefit of adult spinal deformity surgery may be particularly reliably predicted. As a result, direct economic benefits may be readily included in cost-effectiveness calculations.

This study had potential limitations. Due to the retrospective design, it is possible that our results may be influenced by confounding factors. Further, while our cohort was derived from a multicenter database of adult spinal deformity, the results may not necessarily be extrapolatable to countries not included in our sample. European countries were notably not represented among our cohort. Additionally, a reasonable proportion of our patients were lost to follow-up. It is possible that differences in likelihood of persistent follow-up at 2 years postoperatively may have influenced our results. In particular, we suspect that the consistent trend towards improvement in HRQOL at 6-month follow-up among the NONOP cohort may be due to poor persistence among that cohort. It was for this reason that we analyzed outcomes only at 2 years, though we cannot exclude the possibility that these dynamics were present at that point as well. Finally, the questions used in this study were components of a larger questionnaire, and have not necessarily been validated for use individually. Questions 9 and 17 do, however, account for 20% each of the function and pain SRS-22r subscores, respectively—

while an imperfect proxy for individual question validation, this directionally supports use of the questions individually.

## CONCLUSION

ASD patients managed operatively exhibited an average increase in work/school productivity of 18.1% and decreased absenteeism of 1.1 per 90 days at 2-year follow-up, while patients managed nonoperatively did not exhibit change from baseline. Given the age distribution of patients in this study, these findings should be interpreted as pertaining primarily to obligations at work or within the home, though the effect was durable across all examined age groups. This study suggests that ASD surgery may be associated with direct benefit to both patients and society via increased economic participation. Further study of the direct and indirect economic benefits of ASD surgery is warranted.

## ➤ Key Points

- ❑ We hypothesized that ASD surgery would be associated with improved work- and school-related productivity, as well as decreased rates of absenteeism.
- ❑ ASD patients managed operatively exhibited an average increase in work/school productivity of 18.1% and decreased absenteeism of 1.1 per 90 days at 2-year follow-up, while patients managed nonoperatively did not exhibit change from baseline.
- ❑ Given the age distribution of patients in this study, these findings should be interpreted as pertaining primarily to obligations at work or within the home.

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