North American Spine Society Journal (NASSJ) 11 (2022) 100132

Contents lists available at ScienceDirect

North American Spine Society Journal (NASSJ)

journal homepage: www.elsevier.com/locate/xnsj

Clinical Studies

Increase in surgeons performing outpatient anterior cervical spine surgery leads to a shift in case volumes over time☆

Abhinaba Chatterjee[a], Nada Rbil[b], Michael Yancey[b], Matthew T. Geiselmann[c], Benjamin Pesante[d], Sariah Khormaee[a,b,*]

[a] *Weill Cornell Medical College, New York, NY, United States*
[b] *Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021, United States*
[c] *New York Institute of Technology, College of Osteopathic Medicine, Old Westbury, NY, United States*
[d] *The University of Connecticut School of Medicine, Farmington, CT, United States*

A R T I C L E I N F O

Keywords:
Outpatient spine surgery
ACDF
CDA
Surgeon volume
Surgeon characteristics
Epidemiology

A B S T R A C T

Background: Prior studies have demonstrated an increase in the performance of outpatient anterior cervical surgery. The degree to which this increase is due to volume increase per individual surgeon versus increase in individual surgeons performing outpatient cervical surgery is unknown.

Methods: Patients undergoing anterior cervical discectomy and fusion (ACDF) or cervical disk arthroplasty (CDA) between 2010 and 2018 in NY state were identified. As a comparison we also evaluated trends for inpatient ACDF and CDA. Annual outpatient case volumes were calculated and defined as being high (> 20/year), intermediate (>5 and ≤ 20/year) or low (>1 and ≤ 5/year). Descriptive statistics were used to report temporal trends and Poisson regression was used to test for statistical significance. We also analyzed trends in various operative metrics by surgeon volume.

Results: In 2010, there were 96 surgeons who performed outpatient ACDF or CDA on a total of 1,855 patients. In 2018, this increased to 253 surgeons performing outpatient ACDF or CDA on a total of 3,372 patients. In comparison, there were 350 surgeons performing 6,783 inpatient cases in 2010 and 376 surgeons performing 6,796 inpatient cases in 2018. The average annual outpatient case volume decreased from 18.8 (95% CI, 13.5 – 24.1) to 12.2 (95% CI, 10.0 – 14.3) surgeries per surgeon. The percentage of surgeons with a high case volume also decreased from 30.2% in 2010 to 10.7% in 2018, whereas the percentage with a low case volume increased (32.3% to 49.8%). Differences between high and low volume surgeons in operative time, length of stay and total charges widened over time.

Conclusion: The increase in outpatient anterior cervical surgery appears to be primarily driven by a greater number of surgeons performing ACDF and CDA on an outpatient basis, as opposed to increased case volumes for each surgeon. In contrast, trends for inpatient anterior cervical surgery were stable.

Introduction

There has been a gradual movement towards anterior cervical spine surgery being performed in outpatient settings as opposed to inpatient settings [1–5]. This trend has been observed for a number of orthopedic procedures, as outpatient surgery is associated with significant cost reduction relative to inpatient surgery due to lower length of in-hospital stay and less perioperative morbidity [6–8]. However, the transition to the outpatient setting for anterior cervical spine surgery is controversial due to concern regarding complications, particularly airway compromise or spinal cord compression following postoperative hematoma formation [9–11]. These complications can be life threatening if not recognized and treated promptly [12,13]. A criticism of the outpatient setting has been its low level of postoperative monitoring and limited access to emergency resources, both of which could compromise the management of such complications if they arise [12,13]. Nonetheless, recent studies show that utilization rates for outpatient anterior cervical surgery continue to increase [14–16].

A number of studies conducted over the past decade have demonstrated that following careful patient selection, outpatient anterior cervical surgery can be performed with similar outcomes and morbidity relative to the inpatient setting [17–23]. Thus, the observed increase in outpatient volume may stem from more surgeons performing this pro-

☆ Editor approval req'd do not assign until Ed corr rec'd

* Corresponding author: Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021, United States
E-mail address: khormaees@hss.edu (S. Khormaee).

https://doi.org/10.1016/j.xnsj.2022.100132
Received 19 April 2022; Received in revised form 2 June 2022; Accepted 7 June 2022
Available online 12 June 2022

cedure in the outpatient setting after being convinced by the findings of these studies. On the other hand, surgeon productivity is known to be one of the primary drivers shifting more surgical interventions to the outpatient setting [24]. Outpatient surgery facilities, which include both hospital-based and freestanding ambulatory surgery centers (ASCs), are often more specialized and have staff that are better trained and experienced regarding the nuances of certain procedures [25]. This has been shown to correlate with lower operative times, shorter wait times and overall greater efficiency [26,27]. Data on the characteristics and volumes of spine surgeons are limited, and the extent to which surgeon volume and operative efficiency has played a role in the increasing rate of outpatient anterior cervical spine surgery is uncertain.

The purpose of the present study was to perform an analysis of how the characteristics and volumes of surgeons performing outpatient anterior cervical surgery have changed over time. We aimed to better understand temporal trends in the number of surgeons performing these procedures relative to the volume of surgeries per surgeon.

Methods

Data source

The New York Statewide Planning and Research Cooperative System (SPARCS) is an administrative database of all emergency department (ED), inpatient and ambulatory surgery records in New York State [28]. Data elements include patient demographics, diagnoses and surgical procedures. SPARCS data are deidentified to maintain patient anonymity, but unique patient identification numbers allow for longitudinal tracking of patients over time throughout various facilities in NY state. For this study we retrospectively reviewed cases in the SPARCS database that occurred between 2010 through 2018. We also acquired annual NY state population estimates from the US Census to calculate population-based rates [29].

Surgeon characteristics

Python software was used to query the National Provider Identifier (NPI) [30] and NY State Office of Professions [31] registries to identify surgeons associated with the NPI or NY state license numbers that appeared on claims. Using these registries, we were able to extract various surgeon characteristics, including specialty designation and year of licensure.

Inclusion and exclusion criteria

We identified all adult patients (at least 18 years of age) who underwent ambulatory anterior cervical discectomy and fusion (ACDF) or cervical disk arthroplasty (CDA) using Current Procedural Terminology (CPT) codes. ACDF was identified using CPT codes 22551, 22554 and 63075 [18], while CDA was identified using CPT codes 22556 and 22558 [32]. Multilevel procedures were differentiated using the CPT code 22552. Patients with codes indicating primary or concurrent posterior cervical arthrodesis, revision fusion, or a diagnosis of trauma or tumor were also excluded. Finally, we excluded patients with missing physician license identifiers due to the inability to identify surgeons performing their procedures.

As a comparison we also identified all adult patients who underwent inpatient ACDF or CDA using the *International Classification of Diseases*, 9th (ICD-9) and 10th (ICD-10) revision procedural coding system (PCS). ACDF was identified using ICD-9 procedure code 81.02 and ICD-10 procedure codes 0RG10A0 and 0RG20A0, while CDA was identified using ICD-9 procedure code 84.62 and ICD-10 procedure code 0RR30JZ [33].

Outcomes

Our primary outcome was the annual number of surgeons performing outpatient ACDF or CDA per capita. Our secondary outcome was the annual volume of outpatient ACDF or CDA for each surgeon. Average annual outpatient case volumes were calculated by dividing the total number of outpatient cases for each surgeon by the number of years during which each surgeon's license appeared on ambulatory claims. We subsequently defined these outpatient case volumes as being high (> 20 per year), intermediate (> 5 and ≤ 20 per year) or low (> 1 and ≤ 5 per year). Trends in various surgeon characteristics, including specialty designation and year of licensure were also evaluated. We also performed subgroup analyses in which we analyzed trends in various operative metrics, including operative time, length of stay, 30-day readmission rates and 1-year reoperation rates stratified by surgeon volume. Causes of 30-day readmissions were reviewed using International Classification of Diseases (ICD) 9th and 10th revision principal diagnosis codes and further categorized into those that were surgical site related, such as postoperative hematoma, site-infection, implant failure, or wound disruption, and non-surgical site related.

Statistical analysis

Differences in baseline characteristics were compared using the Chi-squared test for categorical data. The Student's *t*-test was used for comparisons of continuous variables between 2 groups, while analysis of variance tests were used for comparing continuous variables across more than 2 groups. Descriptive statistics were used to report temporal trends for the number of surgeons performing outpatient ACDF or CDA and annual surgeon volume. Average annual percent changes were calculated for each trend, and Poisson regression was used to test for the statistical significance of trends. The Cochran-Armitage test was used to test for trends in proportions of surgeons in each annual volume category over time. In subgroup analyses, we assessed for interactions between time and surgeon volume using linear regression models that included the year of discharge as a covariate. P-values < 0.05 were considered statistically significant. All analyses were two-tailed and conducted using Stata MP software version 17.0 (StataCorp, TX, USA).

Ethics

The institutional review board and ethical committee at Weill Cornell Medicine gave approval to conduct this study. The study was conducted and reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) checklist and study guidelines.

Results

Between 2010 – 2018, a total of 588 unique surgeons performed either outpatient or inpatient ACDF or CDA on 88,544 patients. Of these, 464 surgeons (79%) performed outpatient ACDF or CDA on 19,467 patients (22%). Among surgeons performing outpatient surgery, there were 34 (7.3%), 124 (26.7%) and 306 (65.9%) who had a high, intermediate and low average annual outpatient case volume, respectively (Table 1). High volume surgeons performed more than half (10,011, [51.4%]) of all outpatient ACDF or CDA during the study period, compared to 6786 (34.9%) and 2670 (13.7%) cases for intermediate and low volume surgeons, respectively. Most surgeons were trained in neurosurgery (263, 56.7%) and had less than 10 years of experience since licensure (228, 49.1%). There were no differences in specialty training or years since licensure by average annual case volume.

High volume surgeons were more likely to have patients who were women (Table 2; 53.3% vs. 49.6%; $P < 0.001$) with higher comorbidity burden (mean Charlson score 0.28 [95% CI, 0.27–0.29] vs. 0.24 [95% CI, 0.23–0.25]; $P < 0.001$) compared to intermediate or low volume surgeons. High volume surgeons also had a higher frequency of performing procedures with more operative levels (34.3% vs. 27.9% for >2-levels; $P < 0.001$) and performed more ACDFs relative to CDAs (97.1% vs.

Table 1
Baseline Characteristics of Surgeons Performing Outpatient Anterior Cervical Surgery by Volume [a].

		High Volume (n = 34)	Intermediate Volume (n = 124)	Low Volume (n = 306)	P-value
Surgeon experience	> 20 years	8 (23.5)	30 (24.2)	96 (31.4)	0.26
	> 10 years and <= 20 years	11 (32.4)	26 (21.0)	65 (21.2)	0.32
	<= 10 years	15 (44.1)	68 (54.8)	145 (47.4)	0.31
surgeon specialty	orthopedic surgery	15 (44.1)	51 (41.1)	135 (44.1)	0.85
	Neurological surgery	19 (55.9)	73 (58.9)	171 (55.9)	0.85

All values are represented as No. (%) unless otherwise specified.
[a] Refers to average annual case volume. Abbreviations: None.

Table 2
Baseline Characteristics of Patients Undergoing Outpatient Anterior Cervical Surgery by Surgeon Volume.

	High Volume	Intermediate Volume	Low Volume	P-value
Number of patients	10,011	6786	2670	
Age, years				0.11
	18–44	3092 (30.9)	2176 (32.1)	895 (33.5)
	45–54	3863 (38.6)	2534 (37.3)	954 (35.7)
	55–64	2457 (24.6)	1621 (23.9)	627 (23.5)
	65+	597 (6.0)	455 (6.7)	193 (7.2)
Sex				< 0.001
	Women	5338 (53.3)	3351 (49.4)	1341 (50.2)
	Men	4673 (46.7)	3435 (50.6)	1329 (49.8)
Charlson comorbidity score, mean (95% CI)	0.28 (0.27, 0.29)	0.24 (0.23, 0.26)	0.25 (0.22, 0.27)	< 0.001
Indications for surgery				
disk herniation	7439 (74.3)	5091 (75.0)	2030 (76.0)	0.17
Stenosis	1619 (16.2)	1434 (21.1)	670 (25.1)	< 0.001
Myelopathy	1303 (13.0)	1144 (16.9)	483 (18.1)	< 0.001
Number of operative levels				< 0.001
	1	6570 (65.6)	4816 (71.0)	1996 (74.8)
	2	2973 (29.7)	1804 (26.6)	647 (24.2)
	3+	468 (4.7)	166 (2.4)	27 (1.0)
Type of surgery				
ACDF	9721 (97.1)	6108 (90.0)	2479 (92.9)	< 0.001
CDA	309 (3.1)	742 (10.9)	198 (7.4)	< 0.001

All values are represented as No. (%) unless otherwise specified.
Abbreviations: CI, confidence interval; ACDF, anterior cervical discectomy and fusion; CDA, cervical disk arthroplasty.

90.8%; P < 0.001). Compared to the inpatient setting, patients undergoing surgery in the outpatient setting were younger (mean age, 49.2 [95% CI, 49.1–49.3] vs. 52.5 [95% CI, 52.4–52.6]; P < 0.001) and had lower comorbidity burden (mean Charlson score, 0.26 [95% CI, 0.25–0.27] vs. 0.58 [95% CI, 0.57–0.59]; P < 0.001). The largest differences in comorbidity burden were seen in the prevalence of diabetes mellitus (8.8% [95% CI, 8.4–9.2%] vs. 15.0% [95% CI, 14.8–15.3%]; P < 0.001), cardiac conditions (1.5% [95% CI, 1.3–1.6%] vs. 4.5% [95% CI, 4.3 – 4.7%]; P < 0.001), and cancer (0.1% [95% CI, 0.05–0.1%] vs. 1.3% [95% CI, 1.2–1.4%]; P < 0.001).

In 2010, there were 96 surgeons who performed outpatient ACDF or CDA on a total of 1855 patients (Fig. 1). In 2018, this increased to 253 surgeons performing outpatient ACDF or CDA on a total of 3372 patients. The annual number of surgeons performing outpatient surgery per capita increased from 4.9 to 13.0 surgeons per million person-years (average annual percent change of 13.3%; P < 0.001), while the annual rate of patients undergoing outpatient ACDF or CDA per capita increased from 98.2 to 157.6 per million person-years (average annual percent change of 8.1%; P < 0.001). Over the same time period the average annual anterior cervical outpatient case volume decreased from 18.8 (95% CI, 13.5 – 24.1) to 12.2 (95% CI, 10.0 – 14.3) surgeries per surgeon (P < 0.001).

In comparison, from 2010 to 2018 the number of surgeons performing inpatient ACDF or CDA increased from 350 to 376, and the number of patients undergoing inpatient surgery increased from 6783 to 6796. This corresponded to a marginal increase in the number of surgeons doing inpatient surgery per capita (18.0 to 19.3 surgeons per million person-years [average annual percent change of 0.9%; P < 0.001]). The average annual percent change for the number of surgeons doing inpatient surgery was lower compared to outpatient surgery (P < 0.001). There was also no change in the average annual inpatient case volume per surgeon over time (19.4 [95% CI, 17.2 – 21.5] to 18.1 [95% CI, 15.7 – 20.4] surgeries per surgeon; P = 0.76).

There was a shift in the distribution of outpatient case volumes over time, as the percentage of surgeons that had a high outpatient case volume decreased from 30.2% in 2010 to 10.7% in 2018 (Table 3; P < 0.001), whereas the percentage with a low case volume increased (32.3% to 49.8%; P < 0.001). The percentage with an intermediate case volume did not change (37.5% to 39.5%; P = 0.52). There were no changes in the experience level of surgeons throughout the study period. However, the proportion of surgeons trained in orthopedic surgery increased from 33.3% in 2010 to 43.9% in 2018 (P = 0.02).

Surgeons with high average annual outpatient case volumes had lower operative times, length of stay and total charges (Table 4). There were no differences in 30-day readmission rates or 1-year reoperation rates. Causes of 30-day readmissions were similar among high and low or intermediate volume surgeons, as there were no differences in the readmission rate for surgical site related causes (0.86% [95% CI, 0.68–1.0%] for high volume vs. 0.91% [95% CI, 0.72–1.1%] for low or intermediate volume; P = 0.94) and non-surgical site related causes (0.99% [95% CI, 0.80–1.19%] for high volume vs 1.01% [95% CI, 0.81–1.21%] for low or intermediate volume; P = 0.93).

Average operative time, length of stay and total charges increased for all surgeons during the study period (Table 5). The gaps between high volume and low or intermediate volume surgeons widened over time for these three metrics, as each had a statistically significant interaction

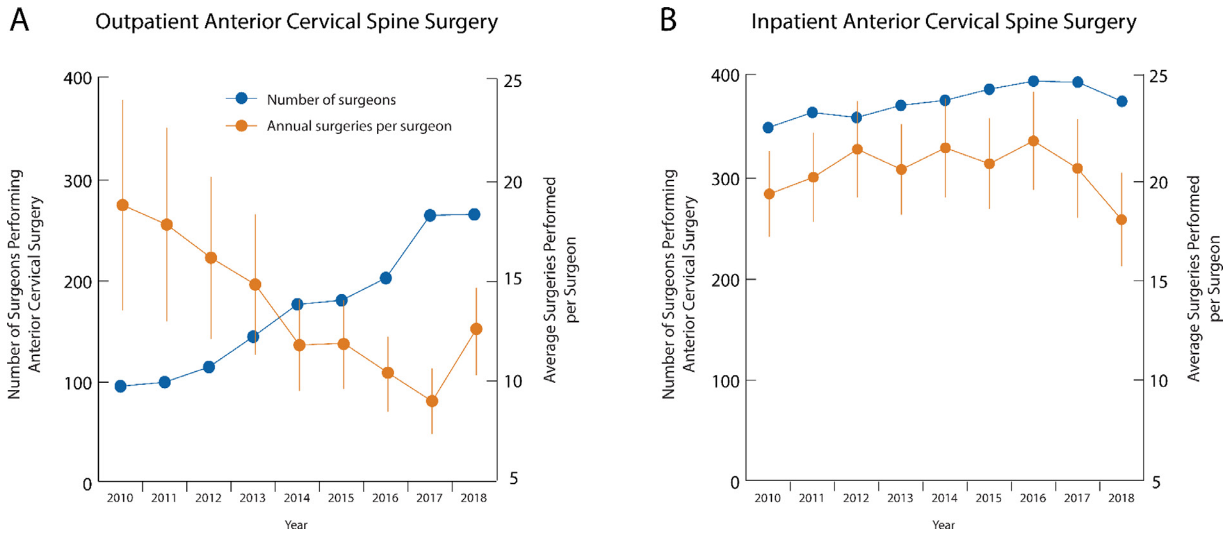

Fig. 1. Temporal trends in the number of surgeons performing anterior cervical spine surgery and annual case volumes per surgeon, Temporal trends are demonstrated for the (A) outpatient setting and (B) inpatient setting. Error bars for average surgeon case volume per year indicate 95% confidence intervals and are included to demonstrate the variation in case volume each year.

Table 3
Temporal Trends in Outpatient Surgeon Volume and Characteristics.

		2010	2011	2012	2013	2014	2015	2016	2017	2018	*P*-value
Total surgeons	96	100	113	144	177	176	201	215	253		
Surgeon	>1 & ≤ 5	31 (32.3)	26 (26)	29 (25.7)	48 (33.3)	76 (42.9)	71 (40.3)	87 (43.3)	100 (46.5)	126 (49.8)	< 0.001
vol-	>5 & ≤ 20	36 (37.5)	44 (44)	53 (46.9)	65 (45.1)	71 (40.1)	78 (44.3)	86 (42.8)	88 (40.9)	100 (39.5)	0.52
ume	>20	29 (30.2)	30 (30)	31 (27.4)	31 (21.5)	30 (16.9)	27 (15.3)	28 (13.9)	27 (12.6)	27 (10.7)	< 0.001
Surgeon	Neurological surgery	64 (66.7)	65 (65)	66 (58.4)	75 (52.1)	94 (53.1)	100 (56.8)	101 (50.2)	111 (51.6)	142 (56.1)	0.02
specialty	Orthopedic surgery	32 (33.3)	35 (35)	47 (41.6)	69 (47.9)	83 (46.9)	76 (43.2)	100 (49.8)	104 (48.4)	111 (43.9)	0.02
Surgeon	≤ 10 years	36 (37.5)	33 (33)	38 (33.6)	51 (35.4)	61 (34.5)	57 (32.4)	67 (33.3)	74 (34.4)	79 (31.2)	0.40
experience	> 10 years & ≤ 20 years	27 (28.1)	27 (27)	28 (24.8)	40 (27.8)	50 (28.2)	56 (31.8)	61 (30.3)	66 (30.7)	85 (33.6)	0.07
	> 20 years	33 (34.4)	40 (40)	47 (41.6)	53 (36.8)	66 (37.3)	63 (35.8)	73 (36.3)	75 (34.9)	89 (35.2)	0.38

All values are represented as No. (%) unless otherwise specified.
[a] Refers to number of surgeries performed each year, as opposed to average annual case volume.

Table 4
Operative Metrics for Outpatient Anterior Cervical Spine Surgery Patients by Surgeon Volume.

	High Volume	Intermediate Volume	Low Volume	*P*-value
Operative time, minutes	172 (0.9)	234 (1.6)	261 (3.4)	< 0.001
Length of stay, hours	19.1 (0.1)	23.8 (0.2)	24.1 (0.3)	< 0.001
Total charges, USD	$26,423 (169)	$43,057 (404)	$46,193 (701)	< 0.001
30-day readmission rate, (%)	1.9% (0.1)	1.7% (0.2)	2.2% (0.3)	0.21
1-year reoperation rate, (%)	2.6% (0.2)	1.9% (0.2)	2.8% (0.3)	0.09

All values are represented as mean (SD) unless otherwise specified.
All values are represented as: mean (SD) unless otherwise specified.
[*] Indicates statistically significant interaction between year of discharge and surgeon volume (dichotomized into high volume vs. low/intermediate volume).
[*]Osperative time was not documented in 2018 SPARCS records.

between year of discharge and surgeon volume in regression models (Table 5). There was no interaction observed for 30-day readmission rates or 1-year reoperation rates.

Discussion

From 2010 to 2018, we observed an increase in the number of surgeons performing outpatient anterior cervical spine surgery in New York state. The increase in the number of surgeons per capita outpaced the increase in the utilization rate for patients undergoing outpatient ACDF or CDA, leading to a downward shift in the distribution of case volumes per surgeon and a decline in mean case volumes over time. This was in contrast to the relatively stable trends observed for inpatient ACDF or CDA.

The transition to the outpatient setting for anterior cervical surgery has been slower and remains low relative to other orthopedic procedures, most likely due to concerns that are unique to anterior cervical exposure [17]. However, over the past decade multiple studies have documented a sharp increase in the volume of outpatient ACDF and CDA, consistent with the findings of the present study [15,16]. Idowu et al. used the Truven Health MarketScan database to show that the percentage of ACDF cases that were being performed outpatient increased from 25% to 33% between 2011 and 2014. Moreover, Lopez et al. found a 180% increase in ambulatory ACDF in the Medicare population between 2015 and 2017.

Table 5
Trends in Operative Metrics for Outpatient Anterior Cervical Spine Surgery Patients, Stratified by Surgeon Volume.

	2010	2011	2012	2013	2014	2015	2016	2017	2018[a]	P-value	
Operative time,	Overall	192.5 (2.84)	189.8 (2.42)	188.4 (2.47)	188.6 (2.38)	208.1 (2.44)	214 (2.21)	221.2 (2.21)	220.4 (2.43)	–	< 0.001
minutes*	Intermediate/ Low volume	254.5 (10.56)	260 (10.75)	249.2 (14.72)	249.3 (11.47)	259.8 (7.61)	265.5 (7.07)	273 (6.54)	274 (6.98)	–	0.09
	High volume	168.7 (2.93)	167.2 (2.47)	166.3 (2.4)	162.2 (2.17)	172.2 (2.37)	189.3 (2.42)	187.5 (2.47)	173 (2.75)	–	< 0.001
Length of stay,	Overall	17.5 (0.29)	18.2 (0.33)	19.2 (0.33)	21.5 (0.28)	22.8 (0.3)	22 (0.31)	22.1 (0.29)	22.3 (0.29)	23.5 (0.27)	< 0.001
hours*	Intermediate/ Low volume	18.6 (0.98)	21.4 (0.87)	21.8 (1.09)	21.9 (0.9)	24.7 (0.71)	20.9 (0.86)	23.3 (0.72)	24.9 (0.66)	26.4 (0.56)	< 0.001
	High volume	15.6 (0.33)	16.1 (0.39)	17.3 (0.38)	19.6 (0.34)	20.2 (0.4)	21.4 (0.42)	20.6 (0.45)	18.9 (0.48)	21.2 (0.49)	< 0.001
Cost, USD*	Overall	$21,171 (214)	$22,613 (220)	$24,054 (307)	$26,882 (328)	$31,504 (413)	$34,167 (471)	$42,189 (629)	$48,114 (790)	$50,599 (691)	< 0.001
	Intermediate/ Low volume	$24,343 (859)	$26,727 (972)	$34,388 (1815)	$35,037 (1625)	$38,232 (1173)	$44,137 (1399)	$48,415 (1544)	$56,350 (2043)	$55,004 (1564)	< 0.001
	High volume	$19,958 (234)	$21,539 (243)	$21,611 (268)	$23,205 (274)	$25,362 (343)	$25,621 (420)	$31,338 (609)	$35,598 (797)	$42,144 (985)	< 0.001
30-day	Overall	2.0 (0.33)	2.3 (0.35)	1.5 (0.28)	2.5 (0.34)	1.7 (0.28)	2.1 (0.3)	1.8 (0.29)	1.8 (0.29)	1.7 (0.23)	0.19
readmission	Intermediate/Low volume	3.5 (0.77)	2.0 (0.58)	1.7 (0.52)	2.6 (0.57)	1.6 (0.39)	1.6 (0.36)	1.7 (0.37)	2.1 (0.41)	1.8 (0.29)	0.16
rate,%	High volume	1.4 (0.33)	2.4 (0.43)	1.3 (0.32)	2.5 (0.41)	1.7 (0.39)	2.6 (0.51)	1.9 (0.46)	1.2 (0.39)	1.4 (0.37)	0.56
1-year	Overall	2.2 (0.34)	2.8 (0.39)	3.4 (0.42)	3.1 (0.38)	2.8 (0.36)	2.6 (0.34)	2.1 (0.31)	1.6 (0.28)	1.3 (0.2)	< 0.001
reoperation	Intermediate/Low volume	2.5 (0.65)	2.5 (0.67)	3.7 (0.75)	2.7 (0.59)	2.7 (0.51)	1.6 (0.36)	2.2 (0.42)	1.2 (0.31)	1.6 (0.28)	0.01
rate,%	High volume	2.0 (0.4)	3.0 (0.49)	3.3 (0.51)	3.3 (0.49)	2.9 (0.51)	3.8 (0.62)	1.9 (0.47)	2.1 (0.53)	0.6 (0.25)	0.002

Several reasons for the increase in outpatient anterior cervical surgery have been hypothesized, including improvements in anesthesia care and surgical techniques, the cost-effective nature of performing surgery on an outpatient basis, and an overall increase in demand for spine surgery due to an aging population [34]. However, few studies have evaluated whether trends in the characteristics of surgeons performing these procedures are associated with the increase in outpatient utilization rates. The study of such trends is important as a consensus on specific approaches in elective spine surgery is often lacking, leading to individual surgeon preferences and characteristics frequently outweighing patient and disease characteristics in influencing each surgeon's decision making [35]. Our study sheds new light on these trends by characterizing the changing dynamics of surgeon training, experience, and case volumes over time in relation to overall utilization for outpatient anterior cervical surgery.

Surgeons that are advocates for the transition to the outpatient setting argue that it allows for cases to be completed more efficiently and cost-effectively, while also allowing for reduced risk of nosocomial complications [36,37]. In particular, the ability to conduct cases in a more time-efficient manner may be appealing to surgeons. Multiple studies have demonstrated that outpatient surgery leads to significantly shorter operative times and wait times, which may lead to an increase in the number of cases that can be performed in a standard workday [24,25]. However, the results of our study show that the growth in the supply of surgeons performing outpatient anterior cervical spine surgery has increased faster than the demand for these procedures. This result is in contrast to the findings of Bederman et al. and Kobayashi et al. [38,39], which studied trends regarding spine surgeon characteristics and practice patterns in Canada and Japan, respectively. Although neither study focused exclusively on cervical spine surgery, both found an increase in case volume per surgeon over time. Our findings are also contrary to trends observed for other orthopedic procedures – a recent study examining temporal trends in surgeon volumes for hip arthroscopy in New York state found an increase in both the number of surgeons performing the procedure and an upward shift in the distribution of case volumes for each surgeon [40]. The authors interpreted these trends as signs of increasing specialization.

An explanation for the trend observed in the present study is that although there are an increasing number of spine surgeons willing to perform outpatient ACDF or CDA, the need for more careful patient selection due to the risk of complications specific to anterior cervical surgery likely precludes surgeons from rapidly identifying new surgical candidates and expanding this aspect of their practice. Consistent with prior studies [17–23], the present study also found significant differences in the age and comorbidity burden between patients undergoing surgery in the inpatient and outpatient setting, with cardiac conditions, diabetes mellitus, and cancer all being significantly higher among patients receiving inpatient surgery. Patients with these comorbidities are more likely to have a higher score on the American Society of Anesthesiology (ASA) Physical Status Classification score, which has been shown to be a risk factor for postoperative hematoma formation [10]. This complication may be devastating in the outpatient setting, where access to emergency resources may be limited. Other less risky spine surgeries or other orthopedic procedures may not have the same patient selection constraints as ACDF or CDA, allowing surgeons to more easily identify new surgical candidates, transition inpatient cases to the outpatient setting and expand their case volumes. However, further studies evaluating more granular metrics are likely required to gain a better understanding of these trends. For example, the present study did not examine the geographic distribution of high volume surgeons; how this geographic distribution has changed over time would likely shed more light on specific areas where surgeons transitioning to the outpatient setting may face greater competition. This topic should be the focus of future studies.

The present study also evaluated the relationship between surgeon volume and important operative metrics. Our results were consistent with estimates of prior studies on this topic, as we found that a higher average annual case volume was associated with lower operative time, length of stay, and total charges [41,42]. Although some prior studies have found higher 30-day readmission rates and 1-year reoperation rates among low volume surgeons, other studies focusing on cervical spine surgery were not able to confirm this association [41]. Importantly, our findings suggest that there is a widening gap between high volume and low or intermediate volume surgeons in operative time, length of stay and total charges over time. This finding may reflect widening inequities in access to high quality care. It is known that access to high volume hospital centers and thus high volume surgeons tends to be restricted to areas with greater socioeconomic resources [43,44], and multiple studies have found widening disparities in quality of care between these regions [45]. More studies are thus needed to assess how changes in case volumes over time may be affecting quality of care.

The strengths of this study include the fact that it evaluates one of the largest longitudinal cohorts of outpatient anterior cervical spine surgery patients to date. Moreover, another strength is our analysis of the SPARCS dataset, which is unique in its inclusion of all ambulatory and inpatient surgery in New York State over the last decade. Therefore, our study evaluates a heterogeneous group of surgeons and surgery centers, which allows for more generalizable results than studies using other registries or samples that include findings from a limited number of centers. Finally, our work also adds to the discussion about ambulatory anterior cervical surgery due to its focus on surgeon volume and characteristics. Despite their importance in influencing utilization rates and outcomes after surgery, few studies have evaluated how these variables have changed over time.

This study also has a number of limitations. Primarily, all observations in this study are limited to New York State, and thus, our findings of decreasing case volumes per surgeon over time may not generalize to other regions. Another limitation is the fact that our study relied on administrative data which have several shortcomings, including unreported or misreported data, the use of ICD-9 and ICD-10 codes to identify patients of interest, the retrospective nature of the study and lack of more granular clinical data such as each patient's imaging findings and medication use. However, prior reports have validated that missing or misreported data only affect $< 5\%$ of data entries in SPARCS, and we used validated code algorithms from prior studies whenever possible.

Conclusion

From 2010 to 2018, there was an increase in the number of surgeons performing outpatient anterior cervical spine surgery in New York state. The increase in the number of surgeons per capita outpaced the increase in the utilization rate for patients undergoing outpatient ACDF or CDA, leading to a decline in mean case volumes per surgeon over time. In contrast, trends for inpatient ACDF or CDA were relatively stable during this time period. High volume surgeons had lower operative time, length of stay and total charges compared to low or intermediate volume surgeons, and there was a widening gap for these three metrics observed over time.

Summary sentence

From 2010 to 2018, the increase in the number of surgeons performing outpatient anterior cervical spine surgery outpaced the increase in the utilization rate for patients undergoing outpatient ACDF or CDA, while trends for inpatient ACDF or CDA remained relatively stable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors report no sources of funding for the present study.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.xnsj.2022.100132.

References

[1] Silvers HR, Lewis PJ, Suddaby LS, Asch HL, Clabeaux DE, Blumenson LE. Day surgery for cervical microdiscectomy: is it safe and effective. J Spinal Disord 1996;9(4):287–93.
[2] Garringer SM, Sasso RC. Safety of Anterior Cervical Discectomy and Fusion Performed as Outpatient Surgery. Clin Spine Surg 2010;23(7):439–43. doi:10.1097/BSD.0b013e3181bd0419.
[3] Epstein NE. Cervical spine surgery performed in ambulatory surgical centers: are patients being put at increased risk? Surg Neurol Int 2016;7(25):S686–91 Suppl. doi:10.4103/2152-7806.191078.
[4] Chin KR, Pencle FJR, Seale JA, Pencle FK. Clinical Outcomes of Outpatient Cervical Total Disc Replacement Compared With Outpatient Anterior Cervical Discectomy and Fusion. Spine 2017;42(10):E567. doi:10.1097/BRS.0000000000001936.
[5] Alvi MA, Wahood W, Kurian SJ, et al. Comparison of economic outcomes data from a state-level database for outpatient lumbar decompression performed in an ambulatory surgery center or hospital outpatient setting. J Neurosurg Spine 2021;35(6):787–95. doi:10.3171/2021.2.SPINE201820.
[6] Best MJ, Buller LT, Eismont FJ. National Trends in Ambulatory Surgery for Intervertebral Disc Disorders and Spinal Stenosis: a 12-Year Analysis of the National Surveys of Ambulatory Surgery. Spine 2015;40(21):1703–11. doi:10.1097/BRS.0000000000001109.
[7] Crawford DC, Li CS, Sprague S, Bhandari M. Clinical and Cost Implications of Inpatient Versus Outpatient Orthopedic Surgeries: a Systematic Review of the Published Literature. Orthop Rev 2015;7(4):6177. doi:10.4081/or.2015.6177.
[8] Naessig S, Kapadia BH, Ahmad W, et al. Outcomes of Same-Day Orthopedic Surgery: are Spine Patients More Likely to Have Optimal Immediate Recovery From Outpatient Procedures? Int J Spine Surg 2021;15(2):334–40. doi:10.14444/8043.
[9] O'Neill KR, Neuman B, Peters C, Riew KD. Risk Factors for Postoperative Retropharyngeal Hematoma After Anterior Cervical Spine Surgery. Spine 2014;39(4):E246. doi:10.1097/BRS.0000000000000139.
[10] Bovonratwet P, Fu MC, Tyagi V, et al. Incidence, Risk Factors, and Clinical Implications of Postoperative Hematoma Requiring Reoperation Following Anterior Cervical Discectomy and Fusion. Spine 2019;44(8):543–9. doi:10.1097/BRS.0000000000002885.
[11] Schroeder GD, Hilibrand AS, Arnold PM, et al. Epidural Hematoma Following Cervical Spine Surgery. Glob Spine J 2017;7(1_suppl) 120S–6S. doi:10.1177/2192568216687754.
[12] Miccoli G, La Corte E, Pasquini E, Palandri G. Life-threatening delayed arterial hemorrhage following anterior cervical spine surgery: a case report and literature review. Surg Neurol Int 2020;11:124. doi:10.25259/SNI_225_2020.
[13] Sagi HC, Beutler W, Carroll E, Connolly PJ. Airway Complications Associated With Surgery on the Anterior Cervical Spine. Spine 2002;27(9):949–53.
[14] Baird EO, Egorova NN, McAnany SJ, Qureshi SA, Hecht AC, Cho SK. National Trends in Outpatient Surgical Treatment of Degenerative Cervical Spine Disease. Glob Spine J 2014;4(3):143–9. doi:10.1055/s-0034-1376917.
[15] Idowu OA, Boyajian HH, Ramos E, Shi LL, Lee MJ. Trend of Spine Surgeries in the Outpatient Hospital Setting Versus Ambulatory Surgical Center. Spine 2017;42(24):E1429. doi:10.1097/BRS.0000000000002180.
[16] Lopez CD, Boddapati V, Lombardi JM, et al. Recent trends in medicare utilization and reimbursement for anterior cervical discectomy and fusion. Spine J 2020;20(11):1737–43. doi:10.1016/j.spinee.2020.06.010.
[17] Adamson T, Godil SS, Mehrlich M, Mendenhall S, Asher AL, McGirt MJ. Anterior cervical discectomy and fusion in the outpatient ambulatory surgery setting compared with the inpatient hospital setting: analysis of 1000 consecutive cases. J Neurosurg Spine 2016;24(6):878–84. doi:10.3171/2015.8.SPINE14284.
[18] Fu MC, Gruskay JA, Samuel AM, et al. Outpatient Anterior Cervical Discectomy and Fusion is Associated With Fewer Short-term Complications in One- and Two-level Cases: a Propensity-adjusted Analysis. Spine 2017;42(14):1044–9. doi:10.1097/BRS.0000000000001988.
[19] Helseth Ø, Lied B, Halvorsen CM, Ekseth K, Helseth E. Outpatient Cervical and Lumbar Spine Surgery is Feasible and Safe: a Consecutive Single Center Series of 1449 Patients. Neurosurgery 2015;76(6):728–38. doi:10.1227/NEU.0000000000000746.
[20] Martin CT, Pugely AJ, Gao Y, Mendoza-Lattes S. Thirty-Day Morbidity After Single-Level Anterior Cervical Discectomy and Fusion: identification of Risk Factors and Emphasis on the Safety of Outpatient Procedures. J Bone Joint Surg Am 2014;96(15):1288–94. doi:10.2106/JBJS.M.00767.
[21] McClelland S, Oren JH, Protopsaltis TS, Passias PG. Outpatient anterior cervical discectomy and fusion: a meta-analysis. J Clin Neurosci 2016;34:166–8. doi:10.1016/j.jocn.2016.06.012.
[22] McGirt MJ, Rossi V, Peters D, et al. Anterior Cervical Discectomy and Fusion in the Outpatient Ambulatory Surgery Setting: analysis of 2000 Consecutive Cases. Neurosurgery 2020;86(3):E310–15. doi:10.1093/neuros/nyz514.

[23] Purger DA, Pendharkar AV, Ho AL, et al. Outpatient vs Inpatient Anterior Cervical Discectomy and Fusion: a Population-Level Analysis of Outcomes and Cost. Neurosurgery 2018;82(4):454–64. doi:10.1093/neuros/nyx215.
[24] Iweala U, Lee D, Lee R, Weinreb JH, O'Brien JR, Yu W. Characterizing efficiency in the ambulatory surgery setting: an analysis of operating room time and cost savings in orthopaedic surgery. J Orthop 2019;16(6):534–42. doi:10.1016/j.jor.2019.09.012.
[25] Munnich E.L., Parente S.T. Procedures Take Less Time At Ambulatory Surgery Centers, Keeping Costs Down And Ability To Meet Demand Up. *Health Aff (Millwood)*. 2014;33(5):764–9. doi:10.1377/hlthaff.2013.1281.
[26] Mercereau P, Lee B, Head SJ, Schwarz SKW. A regional anesthesia-based "swing" operating room model reduces non-operative time in a mixed orthopedic inpatient/outpatient population. Can J Anesth Can Anesth 2012;59(10):943–9. doi:10.1007/s12630-012-9765-x.
[27] Kolisek FR, McGrath MS, Jessup NM, Monesmith EA, Mont MA. Comparison of Outpatient versus Inpatient Total Knee Arthroplasty. Clin Orthop Relat Res 2009;467(6):1438–42. doi:10.1007/s11999-009-0730-0.
[28] Sheha ED, Salzmann SN, Khormaee S, et al. Patient Factors Affecting Emergency Department Utilization and Hospital Readmission Rates After Primary Anterior Cervical Discectomy and Fusion: a Review of 41,813 cases. Spine 2019;44(15):1078–86. doi:10.1097/BRS.0000000000003058.
[29] Explore Census Data. Accessed March 30, 2022. https://data.census.gov/cedsci/.
[30] NPPES NPI Registry. Accessed March 30, 2022. https://npiregistry.cms.hhs.gov/.
[31] NYS Professions - Online Verifications. Accessed March 30, 2022. https://www.op.nysed.gov/opsearches.htm
[32] Upadhyayula PS, Yue JK, Curtis EI, Hoshide R, Ciacci JD. A matched cohort comparison of cervical disc arthroplasty versus anterior cervical discectomy and fusion: evaluating perioperative outcomes. J Clin Neurosci 2017;43:235–9. doi:10.1016/j.jocn.2017.04.027.
[33] Neifert SN, Martini ML, Yuk F, et al. Predicting Trends in Cervical Spinal Surgery in the United States from 2020 to 2040. World Neurosurg 2020;141:e175–81. doi:10.1016/j.wneu.2020.05.055.
[34] Ahn J, Bohl DD, Tabaraee E, Basques BA, Singh K. Current Trends in Outpatient Spine Surgery. Clin Spine Surg 2016;29(9):384–6. doi:10.1097/BSD.0000000000000417.
[35] Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, Major Medical Complications, and Charges Associated with Surgery for Lumbar Spinal Stenosis in Older Adults. JAMA J Am Med Assoc 2010;303(13):1259–65. doi:10.1001/jama.2010.338.
[36] Pugely AJ, Martin CT, Gao Y, Mendoza-Lattes SA. Outpatient Surgery Reduces Short-Term Complications in Lumbar Discectomy: an Analysis of 4310 Patients From the ACS-NSQIP Database. Spine 2013;38(3):264–71. doi:10.1097/BRS.0b013e3182697b57.
[37] Wohns R. Safety and cost-effectiveness of outpatient cervical disc arthroplasty. Surg Neurol Int 2010;1:77. doi:10.4103/2152-7806.73803.
[38] Bederman SS, Kreder HJ, Weller I, Finkelstein JA, Ford MH, Yee AJM. The who, what and when of surgery for the degenerative lumbar spine: a population-based study of surgeon factors, surgical procedures, recent trends and reoperation rates. Can J Surg 2009;52(4):283–90.
[39] Kobayashi K., Sato K., Kato F., et al. Trends in the numbers of spine surgeries and spine surgeons over the past 15 years. Published online February 2022. Accessed March 30, 2022. doi:10.18999/nagjms.84.1.155.
[40] Schairer WW, Nwachukwu BU, Suryavanshi JR, Yen YM, Kelly BT, Fabricant PD. A Shift in Hip Arthroscopy Use by Patient Age and Surgeon Volume: a New York State–Based Population Analysis 2004 to 2016. Arthrosc J Arthrosc Relat Surg 2019;35(10):2847–54 e1. doi:10.1016/j.arthro.2019.05.008.
[41] Cole T, Veeravagu A, Zhang M, Ratliff JK. Surgeon Procedure Volume and Complication Rates in Anterior Cervical Discectomy and Fusions. Clin Spine Surg 2017;30(5):E633–9. doi:10.1097/BSD.0000000000000238.
[42] Basques BA, Louie PK, Shifflett GD, et al. Effect of Surgeon Volume on Complications, Length of Stay, and Costs Following Anterior Cervical Fusion. Spine 2017;42(6):394–9. doi:10.1097/BRS.0000000000001756.
[43] Berg S, Tully KH, Sahraoui A, et al. Inequity in selective referral to high-volume hospitals for genitourinary malignancies. Urol Oncol Semin Orig Investig 2020;38(6):582–9. doi:10.1016/j.urolonc.2020.02.013.
[44] Liu JH, Zingmond DS, McGory ML, et al. Disparities in the Utilization of High-Volume Hospitals for Complex Surgery. JAMA 2006;296(16):1973–80. doi:10.1001/jama.296.16.1973.
[45] Dickman SL, Himmelstein DU, Woolhandler S. Inequality and the health-care system in the USA. The Lancet 2017;389(10077):1431–41. doi:10.1016/S0140-6736(17)30398-7.