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Association between Physician Industry Payments and Cost of Anterior Cervical Discectomy and Fusion in Medicare Beneficiaries

Liu, Caterina ; Ahmed, Karim ; Chen, Catherine L ; Dudley, R Adams ; Gonzales, Ralph ; Orrico, Katie ; Yerneni, Ketan ; Stienen, Martin N ; Veeravagu, Anand ; Desai, Atman ; Park, Jon ; Ratliff, John K ; Zygourakis, Corinna C

Abstract: BACKGROUND Neurosurgical spine specialists receive considerable amounts of industry support which may impact the cost of care. The aim of this study was to evaluate the association between industry payments received by spine surgeons and the total hospital and operating room (OR) costs of an anterior cervical discectomy and fusion (ACDF) procedure among Medicare beneficiaries. **METHODS** All ACDF cases were identified among the Medicare Carrier Files, from January 1, 2013, to December 31, 2014, and matched to the Medicare Inpatient Baseline File. The total hospital and OR charges were obtained for these cases. Charges were converted to cost using year-specific cost-to-charge ratios. Surgeons were identified among Open Payments database, which is used to quantify industry support. Analyses was performed to examine the association between industry payments received and ACDF costs. **RESULTS** Matching resulting in the inclusion of 2,209 ACDF claims from 2013-2014. In 2013 and 2014, the mean total cost for an ACDF was 21,798 and 21,008, respectively; mean OR cost was 5,878 and 6,064, respectively. Mann-Whitney U test demonstrated no significant differences in the mean total or OR cost for an ACDF based on quartile of general industry payment received ($p=0.21$ and $p=0.54$), and linear regression found no association between industry general payments, research support, or investments on the total hospital cost ($p=0.41$, $p=0.13$, and $p=0.25$), or OR cost for an ACDF ($p=0.35$, $p=0.24$, and $p=0.40$). **CONCLUSIONS** This study suggests that spine surgeons performing ACDF surgeries may receive industry support without impacting the cost of care.

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Synthes), JP (none), JR (consultant: Stryker Spine, Nuvasive, Medtronic; grant funding: Agency for Healthcare Research and Quality)

Patient Consent: Patient consent was not required.

ABSTRACT:

Background: Neurosurgical spine specialists receive considerable amounts of industry support which may impact the cost of care. The aim of this study was to evaluate the association between industry payments received by spine surgeons and the total hospital and operating room (OR) costs of an anterior cervical discectomy and fusion (ACDF) procedure among Medicare beneficiaries.

Methods: All ACDF cases were identified among the Medicare Carrier Files, from January 1, 2013, to December 31, 2014, and matched to the Medicare Inpatient Baseline File. The *total hospital* and *OR charges* were obtained for these cases. Charges were converted to cost using year-specific cost-to-charge ratios. Surgeons were identified among Open Payments database, which is used to quantify industry support. Analyses was performed to examine the association between industry payments received and ACDF costs.

Results: Matching resulting in the inclusion of 2,209 ACDF claims from 2013-2014. In 2013 and 2014, the mean total cost for an ACDF was \$21,798 and \$21,008, respectively; mean OR cost was \$5,878 and \$6,064, respectively. Mann-Whitney U test demonstrated no significant differences in the mean total or OR cost for an ACDF based on quartile of general industry payment received ($p=0.21$ and $p=0.54$), and linear regression found no association between industry general payments, research support, or investments on the total hospital cost ($p=0.41$, $p=0.13$, and $p=0.25$), or OR cost for an ACDF ($p=0.35$, $p=0.24$, and $p=0.40$).

Conclusions: This study suggests that spine surgeons performing ACDF surgeries may receive industry support without impacting the cost of care.

Key words: ACDF; anterior cervical discectomy and fusion; claims; healthcare costs; industry; Medicare

INTRODUCTION

Neurosurgery and orthopedic spine surgeons receive a considerable amount of industry support, as reflected in the Open Payments database, with about 91.6% of American spine surgeons reporting at least one financial industry relationship.¹ From August to December 2013, there were 58,127 relationships reported for orthopedic surgeons, at a total value of \$80,157,503, exceeding that of any other subspecialty in medicine.² Royalties and licensing fees, received by only 1.7% of orthopedic surgeons, represented 69.5% of the total monetary value of payment. Among neurosurgeons, 78% had financial relationships with industry, the highest rate of any subspecialty in medicine.²

As demonstrated by the Physician Payments Sunshine Act (PPSA) of 2010, transparency with regard to physician-industry relationships is gaining public attention due to any potential impact on the quality and costs of healthcare. Previous work has shown that there may be an association between industry payments and physician prescribing patterns.^{3,4} However, there has been no work thus far on how industry payments impact the cost and quality of surgical subspecialties, particularly spine surgery, in the United States.

The aim of this study was to determine if industry payments to spine surgeons are correlated with higher surgical costs to Medicare beneficiaries. We elected to look at anterior cervical discectomy and fusion (ACDF) given that it is one of the most common spinal procedures performed, with a well-established surgical approach, high success rate, consistent operative time, and predictable length of hospital stay, as well as high variability in operating room costs.⁵⁻⁷

METHODS

Study Design and Data Inclusion

This study was conducted as a quality improvement initiative and was exempt from human participants review. The Consolidated Health Economic Evaluation Reporting Standards (CHEERS) guidelines were followed for this study. Patient consent was not required, as this was a retrospective analysis of costs obtained through the Medicare databases. CPT code was utilized to identify inpatient anterior cervical discectomy and fusion (ACDF) claims from the 2013-2014 Medicare Carrier Files (CPT 22551; CPT 22552 was not excluded), which contains a 5% sample of all national claims by physicians and clinics for services.⁸ These cases were then matched to the Medicare Inpatient Baseline File, by physician NPI number. Among the included hospitalizations, the *total hospital and operating room (OR) charges* (in U.S. dollars) was obtained from the Medicare Revenue File.⁹ We chose to analyze elective anterior cervical discectomy and fusion (ACDF) given that it is one of the most common spinal procedures performed, with a well-established surgical approach, high success rate, consistent operative time, and predictable length of hospital stay, as well as high variability in operating room costs.⁵⁻

Charges were converted to cost using year-specific cost-to-charge ratios. The physician's full name, city, and state was used to match the operating surgeon in the Medicare Carrier File to the Open Payments File¹⁰—a database of 814,447 physicians submitted by organizations and companies to Medicare, which outlines industry support received by physicians. ACDF claims with complete information for all of these datasets were included in the final analysis. For each surgeon, industry support, including general payments, research support, and stock ownership (in U.S. dollars) was derived from the 2013 – 2014 Open Payments File.

Measures of Surgical Cost

Inpatient claims associated with carrier file ACDF claims were identified, the inpatient claim number obtained, and revenue associated with those inpatient claim numbers were extracted for claims that met all inclusion criteria.

For each physician, the mean *total hospital cost* for ACDF (in U.S. dollars) was determined. The total hospital charge for each ACDF patient was obtained from the Medicare inpatient charge file and converted to cost using the year-specific cost-to-charge ratio (CCR). CCR, included in the Medicare Impact File for IPPS Fiscal Year 2013¹¹ and 2014¹², was calculated as the sum of the Operating CCR and Capital CCR.

The *operating room cost* for ACDF for each physician was determined by converting the operating room charges from the Medicare revenue files into cost using the appropriate CCR.

Measures of Industry Payments

First name, last name, city, and state of a treating physician was used to link the physicians from the Medicare files to the Open Payments database (January 1, 2013 through December 31, 2014). Open Payments is a publicly available database that includes all reported industry payments to clinicians. Payments are categorized into *general payments* (i.e., payments not associated with research, which may include food and drink, travel, consulting, or speaker fees), *research payments* (i.e., payments associated with research), and *ownership* (including royalties, patents, and stock related to industry). All payments are expressed in U.S. dollars.

Statistical Analysis

The Mann-Whitney U test was performed to compare medians, or means, for continuous variables between groups, and the Fisher's exact test or Chi square test was performed on categorical variables to compare frequencies/percentages between the two groups. A Kruskal-Wallis one-way analysis of variance (ANOVA) was used to compare medians or means across multiple groups. Results are described as mean $\pm$ standard deviation unless otherwise specified. A P -value < 0.05 was considered statistically significant. Statistical analysis was performed using either GraphPad Prism (La Jolla, CA) or R (Vienna, Austria) software.

RESULTS

Claims Included

The CPT code for ACDF, '22551', was utilized to retrospectively identify 1,857 claims from 2013 and 1,886 from 2014, in the Medicare Carrier Files. Following matching to Medicare Inpatient Files, 1,696 patients and 1,682 patients from 2013 and 2014 were included, respectively. After matching to CCR and Medicare Profile files, 1,626 and 1,609 patients were included. Medicare Inpatient Files, Carrier, CCR, and Revenue matching led to the inclusion of 1,615 and 1,601 providers from 2013 and 2014, respectively. Finally, matching to the Open Payments file was performed, resulting in 1,062 and 1,147 claims included (**Figure 1**).

Total Cost and Operating Room Cost of an ACDF

In 2013, the mean and median Medicare total cost for an ACDF was \$21,798.91 (\$3,843.65 – \$30,5344.10) and \$16,352.66 (\$12,034.25; \$23,179.53), respectively. The mean and median total cost for an ACDF in 2014 was \$21,008.28 (\$1,868.65 – \$16,3502.20) and \$16,592.69 (\$12,142.26; \$23,445.32). The mean and median Medicare operating room (OR) costs for the

same procedure, in 2013, was \$5,878.28 (\$66.30 – \$50,850.28) and \$4,531 (\$3,071.72; \$7,071.19). In 2014, the mean and median OR cost for an ACDF was \$6,063.85 (\$384.75 – \$65,345.50) and \$4845.26 (\$3170.41; \$7,151.67). There were no significant differences between the total or OR costs between 2013 and 2014 ($p=0.43$ and $p=0.51$, respectively) (**Table 1**).

Costs of an ACDF by Quartile of General Industry Payments Received

Each quartile of industry payments was compared to the Medicare total cost and OR costs.

General industry payment quartiles were divided into categories by the amount received: $\leq \$147$ (Q1), \$147 - \$1,033 (Q2), \$1,033 – \$9,523 (Q3), and $\geq \$9,523$ (Q4). (Figure 2). Kruskal-Wallis ANOVA demonstrated that there were no significant differences in the mean OR cost for an ACDF, based on the quartile of general industry payment received by the treating surgeon ($p=0.54$). In addition, there were no significant differences in the mean total cost of an ACDF operation, based on quartile of industry payment received either ($p=0.21$) (**Figure 2**).

General Industry Payment, Industry Research Support, and Industry Investments versus ACDF Costs

For the years 2013 and 2014 ($N=2,209$), linear regression and Mann-Whitney U test indicated there was no significant association between general industry payments, industry research support, or industry investments received on either the median total cost ($p=0.41$, $p=0.13$, and $p=0.25$, respectively) or the median OR cost of an ACDF ($p=0.35$, $p=0.24$, and $p=0.40$, respectively) (**Figure 3**).

DISCUSSION

1 Considering that orthopedic surgeons receive the greatest total value of industry support and
2 neurosurgeons represent the highest proportion of industry relationships, it is important for us to
3 analyze the implications of industry support on the field and cost of spinal surgery.^{1,2} Our current
4 study revealed no association between industry payments received by spine surgeons and the
5 total hospital cost, or operating room cost, of an ACDF operation in Medicare patients. When
6 stratified by quartile of industry payment received, there were no significant differences in either
7 the mean or median total cost, or operating room cost, for an ACDF. General industry payments,
8 industry research support, or industry stock ownership by the treating physician was also
9 independent of the total and OR costs for an ACDF.

10 In contrast to the current study, previous work has demonstrated a significant association
11 between industry payments and physician prescribing patterns.^{3, 4, 13-15} One of the most cited
12 examples is a Medicare database analysis of 2,444 Massachusetts physicians prescribing statins.
13 The study found that total industry payments, in U.S. dollars, and industry payments for
14 educational training were significantly associated with an increased prescribing rate for a
15 particular brand statin.³ However, these findings may not be generalizable to all of medicine as
16 the nature and frequency of industry relationships vary substantially across specialties and the
17 nature of practice.¹⁴ Interestingly, spine surgeon demographics and location of practice may be
18 associated with industry relationships. A recent study of 5,898 spine surgeons in the Open
19 Payments database found that orthopedic (versus neurosurgery) training, academic practice
20 setting, male gender, practice in the Western or Southern U.S., and younger age were strongly
21 associated with industry relationships.¹

22 Another recent study found that most surgeons were not aware of operative costs and
23 that, when implemented, cost feedback was significantly associated with a reduction in the cost

1 of surgical supplies.¹⁶ As such, cost feedback may be an integral step towards curbing the cost of
2 expensive surgical procedures like spinal fusions. Of note, there is previous literature in this area
3 that characterizes Open Payments data and the nature of industry relationships for various
4 surgical specialties, including orthopedic and neurosurgery.¹⁷⁻²⁰ However, to the authors'
5 knowledge, this is the first study to assess any association between industry support and
6 operative costs for a surgical specialty.

7 Although the current study found no association between industry-funded research and
8 surgical costs, spine surgeons should be aware of other potential implications of industry
9 relationships. A retrospective review of 527 articles published in *Spine* revealed that industry-
10 funded research was significantly more likely to report a positive result compared to research
11 from other funding sources.²¹

12 Our work has several limitations inherent to the methodological weaknesses of the
13 Medicare database. Some of the missing data during the matching process was due to the fact
14 that some physicians in the cohort operate at multiple hospitals in different states. However, this
15 was reduced by the attempt to match physicians using the first 4 listed city/state combinations. In
16 addition, the total sample size of 2,209 does not encompass all ACDF operations performed in
17 2013 and 2014, and is rather a representative sample from the 5% Medicare carrier claim file.
18 Another source of variation is that although CMS's total payment to hospitals is based on
19 diagnosis related groups (DRGs), the hospital's charges and distribution of OR vs. other
20 inpatient costs is set by the hospital itself.

21 22 **CONCLUSIONS**

This study found that spine surgeons performing ACDF surgeries may receive industry support in the form of general payments, research funding, and stock ownership without impacting the surgical cost of care for Medicare beneficiaries. To the authors' knowledge, this is the first study to assess the association between industry support and operative costs for a surgical specialty.

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REFERENCES

1. Weiner JA, Cook RW, Hashmi S, et al. Factors Associated With Financial Relationships Between Spine Surgeons and Industry: An Analysis of the Open Payments Database. *Spine (Phila Pa 1976)*. 2017;42(18): 1412-1418. <https://doi.org/10.1097/brs.0000000000002121>.

2. Cvetanovich GL, Chalmers PN, Bach BR, Jr. Industry Financial Relationships in Orthopaedic Surgery: Analysis of the Sunshine Act Open Payments Database and Comparison with Other Surgical Subspecialties. *The Journal of bone and joint surgery American volume*. 2015;97(15): 1288-1295. <https://doi.org/10.2106/jbjs.N.01093>.
3. Yeh JS, Franklin JM, Avorn J, Landon J, Kesselheim AS. Association of Industry Payments to Physicians With the Prescribing of Brand-name Statins in Massachusetts. *JAMA Intern Med*. 2016;176(6): 763-768. <https://doi.org/10.1001/jamainternmed.2016.1709>.
4. Lieb K, Scheurich A. Contact between Doctors and the Pharmaceutical Industry, Their Perceptions, and the Effects on Prescribing Habits. *PLOS ONE*. 2014;9(10): e110130. <https://doi.org/10.1371/journal.pone.0110130>.
5. Gray MJ, Biyani A, Smith A. A retrospective analysis of patient perceived outcomes in patients 55 years and older undergoing anterior cervical discectomy and fusion. *Journal of spinal disorders & techniques*. 2010;23(3): 157-161. <https://doi.org/10.1097/BSD.0b013e31819e31a4>.
6. Buttermann GR. Anterior Cervical Discectomy and Fusion Outcomes over 10 Years: A Prospective Study. *Spine*. 2018;43(3): 207-214. <https://doi.org/10.1097/brs.0000000000002273>.
7. Kani KK, Chew FS. Anterior cervical discectomy and fusion: review and update for radiologists. *Skeletal Radiol*. 2018;47(1): 7-17. <https://doi.org/10.1007/s00256-017-2798-z>.
8. Services CfMaM. Centers for Medicare and Medicaid Services. Standard Analytical Files (Medicare Claims)-LDS.; 2017. <https://www.cms.gov/Research-Statistics-Data-and-Systems/Files-for-Order/LimitedDataSets/StandardAnalyticalFiles.html>. . Accessed November 20 2017.

- 1 9. Services CfMaM. Centers for Medicare and Medicaid Services. Physician Compare
2 Datasets. ; 2017. <https://data.medicare.gov/data/physician-compare>. Accessed November 20
3 2017.
- 4 10. Services CfMaM. Center for Medicare and Medicaid Services. Open Payments Data. ;
5 2017. <https://openpaymentsdata.cms.gov/>. Accessed November 20 2017.
- 6 11. Services CfMaM. Centers for Medicare and Medicaid Services. Impact File for IPPS FY
7 2013 Final Rule.; 2017. [https://www.cms.gov/Medicare/Medicare-Fee-for-Service-](https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Historical-Impact-Files-for-FY-1994-through-Present-Items/Impact-File-for-IPPS-FY2013-Final-Rule.html)
8 Payment/AcuteInpatientPPS/Historical-Impact-Files-for-FY-1994-through-Present-
9 Items/Impact-File-for-IPPS-FY2013-Final-Rule.html. Accessed November 20 2017.
- 10 12. Services CfMaM. Centers for Medicare and Medicaid Services. Impact File for IPPS FY
11 2014 Final Rule; 2017. [https://www.cms.gov/Medicare/Medicare-Fee-for-Service-](https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/FY-2014-IPPS-Final-Rule-Home-Page-Items/FY-2014-IPPS-Final-Rule-CMS-1599-F-Data-Files.htm)
12 Payment/AcuteInpatientPPS/FY-2014-IPPS-Final-Rule-Home-Page-Items/FY-2014-IPPS-Final-
13 Rule-CMS-1599-F-Data-Files.htm. Accessed November 20 2017.
- 14 13. DeJong C, Aguilar T, Tseng CW, Lin GA, Boscardin WJ, Dudley RA. Pharmaceutical
15 Industry-Sponsored Meals and Physician Prescribing Patterns for Medicare Beneficiaries. *JAMA*
16 *Intern Med.* 2016;176(8): 1114-1122. <https://doi.org/10.1001/jamainternmed.2016.2765>.
- 17 14. Grande D. A national survey of physician-industry relationships. *The New England*
18 *journal of medicine.* 2007;357(5): 507-508; author reply 508.
- 19 15. Fleischman W, Ross JS, Melnick ER, Newman DH, Venkatesh AK. Financial Ties
20 Between Emergency Physicians and Industry: Insights From Open Payments Data. *Ann Emerg*
21 *Med.* 2016;68(2): 153-158.e154. <https://doi.org/10.1016/j.annemergmed.2016.01.014>.

16. Zygorakis CC, Valencia V, Moriates C, et al. Association Between Surgeon Scorecard Use and Operating Room Costs. *JAMA Surg.* 2017;152(3): 284-291. <https://doi.org/10.1001/jamasurg.2016.4674>.
17. Rathi VK, Samuel AM, Mehra S. Industry ties in otolaryngology: initial insights from the physician payment sunshine act. *Otolaryngol Head Neck Surg.* 2015;152(6): 993-999. <https://doi.org/10.1177/0194599815573718>.
18. Samuel AM, Webb ML, Lukasiewicz AM, et al. Orthopaedic Surgeons Receive the Most Industry Payments to Physicians but Large Disparities are Seen in Sunshine Act Data. *Clinical orthopaedics and related research.* 2015;473(10): 3297-3306. <https://doi.org/10.1007/s11999-015-4413-8>.
19. Tierney NM, Saenz C, McHale M, Ward K, Plaxe S. Industry Payments to Obstetrician-Gynecologists: An Analysis of 2014 Open Payments Data. *Obstetrics and gynecology.* 2016;127(2): 376-382. <https://doi.org/10.1097/aog.0000000000001270>.
20. Chang JS. The Physician Payments Sunshine Act: data evaluation regarding payments to ophthalmologists. *Ophthalmology.* 2015;122(4): 656-661. <https://doi.org/10.1016/j.opthta.2014.11.003>.
21. Shah RV, Albert TJ, Bruegel-Sanchez V, Vaccaro AR, Hilibrand AS, Grauer JN. Industry support and correlation to study outcome for papers published in Spine. *Spine.* 2005;30(9): 1099-1104; discussion 1105.

FIGURE LEGENDS

Figure 1: CONSORT Flow diagram for included data. Anterior cervical discectomy and fusion (ACDF) operative cases, between 2013 and 2014, were identified from the Medicare Carrier Files. Matching between the Medicare Carrier files, Medicare Inpatient Baseclaim file, Medicare Cost-to-Charge Ratios (CCR), Medicare Revenue file, and Open Payments led to the inclusion of 1,062 claims from 2013 and 1,147 claims from 2014.

Figure 2: Medicare total costs and OR costs of ACDF operations in 2013 and 2014. There were no significant differences in the mean or median total cost, or OR cost, for an ACDF based on the quartile of general industry payment received by the treating surgeon ($p=0.54$ and $p=0.21$, respectively).

Figure 3: The relationship between general industry payments, industry research support, and industry investments received by the treating surgeon on the costs of an ACDF. For the years 2013 and 2014 ($N=2,209$), there was no significant association between general industry payments, industry research support, or industry investments received by the treating surgeon on either the median total cost ($p=0.41$, $p=0.213$, and $p=0.25$, respectively) or the median OR cost of an ACDF ($p=0.35$, $p=0.24$, and $p=0.40$, respectively).

	2013 (N=1,062)	2014 (N=1,147)	P-value^b
Total Cost of ACDF			
Mean (Range)	\$21,798.91 (\$3,843.65 – \$30,534.10)	\$21,008.28 (\$1,868.65 – \$16,350.20)	>0.05
Median (Q1; Q3)	\$16,352 (\$12,034.25; \$23,179.53)	\$16,592 (\$12,142.26; \$23,445.32)	>0.05
OR Cost of ACDF			
Mean (Range)	\$5,878.28 (\$66.30 – \$50,850.28)	\$6,063.85 (\$384.75 – \$65,345.50)	>0.05
Median (Q1; Q3)	\$4,531.28 (\$3,071.72; \$7,071.19)	\$4,845.25 (\$3,170.41; \$7,151.67)	>0.05

Table 1. Medicare total and OR costs for ACDF operations in 2013 and 2014^a.

Abbreviations: N, number of surgical claims included; OR, operating room; ACDF, anterior cervical discectomy and fusion.

^aStudy period is Jan 1, 2013-Dec 31, 2014. Mean and median costs are rounded to nearest cent.

^bThe Mann-Whitney U test was performed to compare medians, or means, for continuous variables between groups

Median Cost

Median Cost

Medicare OR Costs by Quartile of General Payments, 2013

Median OR Cost

Medicare OR Costs by Quartile of General Payments, 2014

Median OR Cost

2013/2014 Industry Research Payments vs Median Total Cost

2013/2014 Industry Research Payments vs Median OR Cost

2013/2014 Industry Investments vs Median Total Cost

2013/2014 Industry Investments vs Median OR Cost

ACDF = anterior cervical discectomy and fusion

OR = operating room

PPSA = Physician Payments Sunshine Act

CCR = cost-to-charge ratio

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CL: Conceptualization, methodology, software, analysis, data curation, investigation, visualization; KA: conceptualization, methodology, software, analysis, editing, writing, data curation, investigation, visualization; CLC: conceptualization, methodology, editing, investigation; RAD: conceptualization, methodology, editing; RG: conceptualization, methodology, editing; KO: conceptualization, methodology, editing, KY: analysis, writing, visualization, investigation; MNS: conceptualization, methodology, editing; AV: conceptualization, methodology, editing; AD: conceptualization, methodology, editing; JP: conceptualization, methodology, editing, writing, JKR: conceptualization, methodology, editing; CCZ: conceptualization, methodology, investigation, writing, editing, supervision, funding acquisition