Assessing Trends In Industry Payments To Orthopaedic Surgeons: A Sub-Specialty Analysis

Neil Pathak

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Assessing Trends in Industry Payments to Orthopaedic Surgeons: A Sub-Specialty Analysis

A Thesis Submitted to the Yale University School of Medicine in Partial Fulfillment of the Requirements for the Degree of Doctor of Medicine

Neil Pathak
Class of 2020
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Thesis Abstract:

Background: The Open Payments Database (OPD), mandated by the Sunshine Act, is a listing of physician-industry payments. With the growing scrutiny of such transactions, the present study aims to characterize and investigate trends in industry payments to orthopaedic surgeons using four full years of data available. The study assessed payments to four orthopaedic sub-specialties: (1) pediatric surgery, (2) foot and ankle (F&A) surgery, (3) spine surgery, (4) adult reconstructive surgery. As the majority of industry payments were classified as General (other categories are Research and Ownership), the present study primarily focused on General payments.

Methods: Industry payments were characterized by number of compensated surgeons and total industry sum for each sub-specialty. Payments were analyzed annually for median payment per surgeon, sub-type, and geography for each sub-specialty. Due to the non-normal distribution of payments, the top five percent of compensated surgeons in each orthopaedic sub-specialty were studied in depth through median payment per surgeon. The nonparametric Mann-Whitney U tests were used for statistical comparisons.

Results: For each orthopaedic sub-specialty, the number of compensated surgeons increased from 2014 to 2017. The median General payment per compensated surgeon remained stable across the four years for each orthopaedic sub-specialty: pediatric surgery ($201 to $197, p=0.82), orthopaedic spine surgery ($1051 to $978, p=0.561), adult reconstructive surgery ($774 to $612, p=0.093). When considering General, Research, and Ownership payments together, the
median annual industry payment to orthopaedic F&A surgeons remained stable as well ($616 to $336, p=0.084). Additionally, when averaged across the four sub-specialties, 81% of the total compensation was made to the top five percent of compensated surgeons. For pediatric orthopaedic surgeons, the median payment for the top five percent cohort saw a significant increase in median payment ($14,624 to $32,752, p=0.006). Across all specialties, payments attributed to food and beverage made up the majority of industry-surgeon transactions, though less than 10% of the total monetary value. Payments related to education saw significant increases from 2014 to 2017 in each of the four sub-specialties.

**Conclusion:** Though many expected payments to surgeons to decrease under the growing scrutiny of the Sunshine Act, there was no overall change in median payment over four years across four orthopaedic sub-specialties. These findings shed insight into the orthopaedic surgeon-industry relationship in the current age of increased transparency.
Acknowledgements

First, I would like to thank my research mentor Dr. Jonathan Grauer for his mentorship and support throughout my research year and beyond. He is a tireless advocate for his mentees, and I am indebted to him for his mentorship, feedback, and guidance. I learned many skills during my research year, including how to write a scientific paper, how to give an effective podium presentation, and how to communicate data concisely—all skills that I developed through Dr. Grauer’s teaching. He is an outstanding mentor. I hope to emulate Dr. Grauer’s approach to academic medicine in my own career.

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Finally, I would like to thank you parents and sister for their continuous and unconditional support.
**Introduction to Chapters**

Financial relationships between industry and surgeons are prevalent and have potential implications for patient care. These relationships allow for exchange of information and collaboration on innovation. Advantages of such relationships are including end-users in the development of new therapies, technologies, and implants. However, they may also lead to biases that could affect patient care. Nonetheless, the widespread nature of such relationships is highlighted by a 2015 survey of 3167 physicians in six specialties that showed that 94% of those surveyed had some relationship with industry.

Passed with the Affordable Care Act, the Physician Payment Sunshine Act (PPSA) is a federal law enacted in 2010. It aimed to increase transparency of financial relationships between physician and pharmaceutical/device companies. The ultimate goal of the law was to address potential conflicts of interest for healthcare providers. This law requires manufacturers to submit data to the Centers for Medicare and Medicaid Services (CMS) regarding transfers to physicians greater than $10 in value. The data are submitted to the Centers for Medicare and Medicaid Services (CMS) by all drug and device manufacturers. Publicly disclosed data from the OPD now includes the last half of 2013, and the entirety of 2014 through 2018.

Payment data in the OPD is organized into several broad categories: General, Research, and Ownership. General payments, by far the most common class of payment reported, with subtypes defined (ranging from education to royalties to gifts). Research payments include agreements such as grants for studies/trials or personal payments for scientific writing.
Ownership payments include when a physician has a personal stake in a medical company, such as for dividend or capital gains.9

Some physicians have raised concerns about the accuracy of the data in the OPD. Some argue that there is a risk for misinterpretation due to lack of adequate context for each payment.10,11 Further, prior literature suggests patient may not be knowledgeable about industry relationships. Iyer et al. completed a questionnaire-based study that showed that the majority of patients were unaware of their physicians’ financial relationships with companies. Nonetheless, the OPD remains the largest resource of physician-industry relationships available to the public.

The OPD has been studied in a wide range of medical and surgical fields such as cardiology,12 interventional radiology,13 otolaryngology,14,15 and plastic surgery.16 In orthopaedic surgery, the first year of OPD data (2013) was analyzed in three studies.8,17,18 Overall, these studies found that, although most surgeons have a relationship with industry, in most cases the financial payment was small, and a small proportion of surgeons received the majority of industry dollars. Another study found that disclosures at the American Academy of Orthopaedic Surgeons Annual Meeting in 2014 did not match OPD data 35% of the time.19

In other disciplines, more recent data from the OPD have been analyzed to look at trends over time.14,15,20 For instance, in urology, it was found that the number of surgeons with industry relationships stayed similar, but total payments went down between 2014 and 2016.15 Additionally, an evaluation of the OPD in plastic surgery showed a decrease in the number of plastic surgeons holding industry ties and a reduction in total payment from 2013 to 2014.21
has been hypothesized that increased public scrutiny afforded by the OPD was at least in part responsible for the reported trend.

While the pattern of payments in orthopaedic surgery as whole has been studied, the patterns and trends in payments to orthopaedic surgeons over four years of publicly available data had not been previously assessed. This thesis aimed to address these gaps by quantifying and characterizing industry payments over time to four sub-specialties within orthopaedic surgery: pediatric orthopaedic surgery, foot and ankle surgery, spine surgery, and adult reconstructive surgery (Chapters 1-4, respectively). The authors hypothesized that the number of compensated orthopaedic surgeons in each sub-specialty, as well as the median payment per compensated surgeon, would decrease over this time period.
Chapter 1:

Assessment of Industry Payments to Pediatric Orthopaedic Surgeons

This chapter was published as the following manuscript:

Abstract:

**Background:** The Open Payments Database (OPD), mandated by the Sunshine Act, is a national registry of physician-industry transactions. Payments are reported as either General, Research, or Ownership payments. The current study aims to investigate trends in OPD General payments reported to pediatric orthopaedic surgeons from 2014 to 2017.

**Methods:** General industry payments made to pediatric orthopaedic surgeons (as identified by OPD) were characterized by median payment, payment sub-type, and census region. As fewer Research and Ownership payments were made, only payment totals for these categories were determined. General payment data were analyzed for trends using the nonparametric Mann-Whitney U test.

**Results:** For General payments, there was an increase in the number of compensated pediatric orthopaedists from 2014 to 2017 (324 vs 429). Of those compensated, there was no significant change in median payment per compensated surgeon ($201 vs $197; p=0.82).

However, a large percentage of total General payment dollars in pediatric orthopaedics were made to the top 5% of compensated pediatric orthopaedists each year (average 71% of total General industry compensation). For this top 5% group, median General payment per compensated surgeon increased from 2014 ($14,624) to 2017 ($32,752) (p=0.006).

A significant increase in median sub-type aggregate payment per surgeon was observed in the education (p<0.001) and royalty/license (p=0.031) sub-types; a significant decrease was observed for travel/lodging payments (p=0.01). Midwest pediatric orthopaedists received the highest median payment across all years studied.
Few payments for research and ownership were made to pediatric orthopaedists. Four-year aggregate payment totals were $18,151 and $3,223,554 for research and ownership payments, respectively.

**Conclusion:** Many expected payments to surgeons to decrease when put under the public scrutiny of the OPD. Not only was this decrease not observed for General payments to pediatric orthopaedic surgeons during the 2014-2017 period, but also the median General payment to the top 5% increased. These findings are important to note in the current era of increased transparency.
Introduction:

Financial relationships between industry and surgeons are common, and have potential implications on patient care. Advantages of such relationships are including end-users in the development of new therapies, technologies, and implants. Disadvantages may include biases and alterations in clinical practices for those who are financially incentivized. For example, it has been shown that physicians who receive payments from opioid manufactureres prescribe more opioids to Medicare patients, when compared with physicians who do not receive such payments.

The primary approach to address potential biases of such physician-industry relationships has been to increase transparency to ensure that all involved are aware of potential confounding variables and able to make their own inferences about such relationships. To that end, lawmakers enacted the Physician Payments Sunshine Act and the Open Payments Database (OPD) in 2010. This law requires manufacturers to submit data to the Centers for Medicare and Medicaid Services (CMS) regarding transfers of value greater than $10 made to providers.

The OPD has publicly released data from five years: the latter five months of 2013, and the full years of 2014, 2015, 2016, and 2017. Data is grouped into three datasets: General Payments, Research Payments, and Ownership Payments. The General Payments dataset contains payments not made in association with a research agreement (also referred to as nonresearch payments), such as for food/beverage or travel/lodging. The Research Payments dataset contains payments made in association with a research agreement, such as scientific writing or clinical studies. The Ownership Payments dataset contains payments related to physician ownership in a company.
Some physicians have raised concerns about the accuracy of data in the OPD. Additionally, some argue that there is risk for misinterpretation due to lack of adequate context for each payment.\textsuperscript{6,10,11} Nonetheless, the OPD remains the largest resource of physician-industry relationships available to the public.

Greater awareness of public reporting from the OPD may dissuade physicians or industry leaders from engaging in financial relationships. With increased attention being given to this topic over the years, the current study aims to investigate trends in payments to pediatric orthopaedic surgeons reported by the OPD over the four full years for which data is available: 2014 to 2017.

Greater than 99\% of all industry payments to pediatric orthopaedic surgeons were classified as General payments. For this reason, the current study primarily focused its analyses on the General Payments dataset. It was hypothesized that the total number of compensated pediatric orthopaedic surgeons, as well as the value of General payments made to pediatric orthopaedic surgeons, would decrease from 2014 to 2017.
**Methods:**

*Data Source/Study Population*

The current study obtained data from the OPD, a public database created under the Physician Payments Sunshine Act. Analysis of this dataset qualified as nonhuman subject research and was deemed exempt from the Human Institutional Review Board review at our institution.

OPD groups industry payments into three datasets: General Payments, Research Payments, and Ownership Payments, which represent nonresearch payments, research payments, and investment/ownership payments, respectively. Annual data files (2014-2017) for each of the three datasets were downloaded.

Each data entry in the OPD represents an industry payment to a physician, and the specialty of the payment recipient (of which pediatric orthopaedic surgery is a specific category) is chosen by the submitting sponsor and is noted in the OPD. Therefore, payments classified as being made to the physician specialty ‘orthopaedic surgery—pediatric orthopaedic surgery’ were identified and extracted. Each data entry also includes information such as monetary amount, practice location of the physician, and sub-type of payment (i.e. food/beverage). Of note, the following OPD data were not included in our analyses: payments made directly to hospitals and those associated with non-US physicians or non-allopathic/osteopathic physicians.

*Analyses*

The current study focused its analyses on the General Payments dataset. The number of U.S. licensed pediatric orthopaedic surgeons receiving at least one General industry payment was then
calculated by year. Next, all General payments attributed to each pediatric orthopaedic surgeon for each year were summed to determine the median and interquartile range (IQR) of payments per compensated surgeon. The median payment per compensated pediatric orthopaedic surgeon for 2014 was compared to the median payments in 2015, 2016, and 2017.

After determining that the majority of General payment dollars were made to the top five percent of compensated pediatric orthopaedists (Figure 1), the current study determined the median and IQR for the top 5% and remaining 95% of compensated pediatric orthopaedic surgeons. The median payments made to the top 5% and remaining 95% in the years 2015 – 2017 were then compared to the median payments in 2014.

Each payment in the General Payments dataset is classified into different sub-types (Table 2). Of note, payments in the following OPD sub-types were summed under the header ‘speaker fees/serving as faculty’ by the authors: ‘compensation for services other than consulting, including serving as faculty or as a speaker at a venue other than a continuing education program,’ ‘compensation for serving as faculty or as a speaker for an accredited or certified continuing education program,’ and ‘compensation for serving as faculty or as a speaker for a non-accredited and noncertified continuing education program.’ For each sub-type and year, the number of surgeons receiving at least one payment, median sub-type aggregate payment per surgeon, and IQR were calculated. The median aggregate payment per surgeon for each sub-type in the years 2015-2017 were compared to the median aggregate payments for each sub-type in 2014.
Each payment in the General Payments dataset is accompanied with information on physician practice location. The current study thus grouped all compensated pediatric orthopaedic surgeons by U.S. census region (as determined by U.S. Census Bureau). Subsequently, the median payment per compensated pediatric orthopaedic surgeon per U.S. census region was determined. Median payments per census region for 2014 were compared to median payments per census region for 2015, 2016, and 2017.

For the top five percent of compensated pediatric orthopaedists, the number of surgeons receiving payments and the median aggregate annual payment per surgeon per sub-type were determined. Additionally, for this group, the number of surgeons and median annual payment for each census group were calculated.

Four-year monetary aggregate and number of payment transactions per Research and Ownership payment categories were determined using the Research Payments and Ownership Payments datasets, respectively.

As the OPD data does not follow a normal distribution (Shapiro-Wilk test; p<0.001), the Mann-Whitney U nonparametric test was used to compare medians in the current study’s analyses. $P$ value less than 0.05 was used as the threshold for statistical significance. All statistical analyses and construction of figures and tables were performed in Stata 13 (StataCorp, College Station, Texas), Microsoft Excel, and GraphPad Prism.
Results:

*General Industry Payments to Pediatric Orthopaedic Surgeons per Year*

A total of 9639 General industry payments were made to pediatric orthopaedic surgeons from 2014 to 2017. The number of compensated pediatric orthopedic surgeons increased each year, from 324 surgeons in 2014 to 429 surgeons in 2018 (Table 1).

Among all pediatric orthopaedic surgeons, no significant increase in median General payment per surgeon was observed over time from 2014 to 2017 ($201 vs. $197; p=0.82). The overall distribution of payments to pediatric orthopaedic surgeons is shown in Figure 1A. Four-year annual General payment aggregate was $5,835,161 from 2014 to 2017.

It was noted that a large dollar percentage of total General industry payments were made to the top 5% of compensated pediatric orthopaedic surgeons in 2014 (62%), 2015 (73%), 2016 (66%), and 2017 (82%) (Figure 1B). To explore this disparity, trends in payments to the top 5% of compensated surgeons were compared to trends in the remaining 95% of compensated surgeons over time (Table 1, Figure 2). Median payments to the top 5% significantly increased from $14,624 in 2014 to $23,101 in 2016 (p=0.02) and $32,752 in 2017 (p=0.005), reflecting a net $18,128 increase over time (Table 1). In contrast, no significant increases to the remaining 95% of compensated surgeons were observed over time.

*General Industry Payments Characterized by Payment Sub-Type*

The number of pediatric orthopaedic surgeons receiving at least one payment in each sub-type per year is shown in Table 2A. Averaged over the four-year period, the sub-types representing
the greatest proportion of compensated pediatric orthopaedists were ‘food/beverage’ (61.4%), followed by ‘travel/lodging’ (18.4%) and ‘education’ (6.4%). All sub-types saw a net increase in the number of pediatric orthopaedists receiving at least one payment from 2014 to 2017, with the exception of payments related to gifts and grants.

The median aggregate payment per surgeon in each sub-type per year is shown in Table 2B. Significant increases in median aggregate payment from 2014 to 2017 were seen in the ‘education’ ($255 vs. $1615; p<0.001) and ‘royalty/license’ ($10,847 vs. $27,828; p=0.031) sub-types. A significant decrease in median aggregate payment was seen in the ‘travel/lodging’ sub-type ($1058 vs $772; p=0.01). Percent changes in median payment per category comparing 2014 to 2017 values are illustrated in Figure 3.

Considering the top five percent of compensated pediatric orthopaedists per year, the highest proportion of surgeons received payments for food/beverage (89%), followed by travel/lodging (78%), consulting fees (62%), and royalty/license (38%). Median aggregate annual payment per surgeon was highest for royalty/license ($28,823) payments, followed by consulting fees ($15,289), serving as faculty/speaker fees ($7360), and grant ($6750) payments in this group.

The top aggregate payments (Figure 1) for 2014-2017 with major sub-type percentage contribution are $120,006 (royalty/license: 68%; consulting fees: 29%), $136,885 (royalty/license: 72%; consulting fees: 26%), $216,848 (royalty/license: 100%), and $510,322 (royalty/license: 100%), respectively.
General Industry Payments Characterized by Census Region per Year

General industry payments were also assessed by census region. In total, the South had the greatest number of compensated pediatric orthopedic surgeons per year, followed by the West (Table 3).

When comparing 2014 and 2017 data, the highest percent increase in the number of compensated pediatric orthopaedists was observed in the Northeast census region. Median payment per surgeon per census region varied highly between region and year, with no statistically significant trends over time among any of the regions (Table 3). Median payment values per surgeon and year within each region is listed on the census region map in Figure 4. Midwest pediatric orthopaedists received the highest median payment across all years studied.

Considering the top five percent of compensated pediatric orthopaedic surgeons each year in totality, the greatest number of surgeons were in the South census region (median annual payment per surgeon: $24,722), followed by West (median annual payment per surgeon: $21,584), Midwest (median payment per surgeon: $25,340), and Northeast (median annual payment per surgeon: $21,334).

Research and Ownership Industry Payments

From the Research Payments dataset, there were few payments reported (n=7, compared to n=9540 for General payments). Four-year annual Research aggregate payment was $18,151 from 2014 to 2017, with no Research payments made in 2016 and 2017.
From the Ownership Payments dataset, there were also few payments reported (n=23, compared to n=9540 for General payments). Four-year annual Ownership aggregate payment was $3,223,554 from 2014 to 2017.
Discussion:

Previous studies have suggested that physicians’ financial interests can influence their practice.\textsuperscript{4,26,27} In an attempt to increase transparency of industry payments to physicians, the Physician Payment Sunshine Act was enacted and requires reporting of industry payments to physicians.\textsuperscript{7} Since the latter half of 2013, compensation data for all physicians receiving industry payments has been made publicly available through the OPD.\textsuperscript{7}

While prior studies have examined physician industry reimbursement in several surgical subspecialties, including plastic surgery,\textsuperscript{16} neurosurgery,\textsuperscript{28,29} otolaryngology,\textsuperscript{9,14,15,30} urology,\textsuperscript{31} and spine surgery,\textsuperscript{32} to date, no studies have specifically assessed industry payments to pediatric orthopaedists. Additionally, previous studies using the OPD to study orthopaedists in general have used data from only one or two years.\textsuperscript{8,17,18}

Three such investigations have described and characterized industry payments using the initial 2013 release of the OPD.\textsuperscript{8,17,18} An additional study found a 35\% inconsistency rate between physician-reported disclosures at a national orthopaedics conference and industry-reported financial disclosures in the OPD.\textsuperscript{19} However, no studies have examined payments from more recent years in this database—an area of interest for exploring trends over time. Using four years of data from the OPD, the current study sought to examine trends in the amount and type of General payments from industry to pediatric orthopaedists between 2014 and 2017.

Contrary to the hypothesis, the current study identified an increase in the number of pediatric orthopaedic surgeons receiving General payments from industry from 2014 to 2017 (increased
from 324 to 429 compensated surgeons). This is in contrast to the trend observed for plastic surgeons in the early years of the database, which found a significant decrease in the number of plastic surgeons holding industry ties and a reduction in total payment from 2013 to 2014. This could potentially be due to differing attitudes towards industry relationships.

Interestingly, the majority of General payments from industry to pediatric orthopaedists was concentrated to the upper 5% of those compensated (average 71% over the years). In fact, when considering only this upper 5% of compensated pediatric orthopaedic surgeons, median General payments more than doubled from 2014 to 2017 (in contrast to no significant change in the median payment to the remaining 95% of compensated surgeons). The finding that much of industry compensation is concentrated in the top several percent of compensated surgeons has been documented in previous studies of the OPD. The trend observed among the top 5% of those compensated was opposite to what was hypothesized. These increased payments to a select few may represent industry actually increasing ties with specific surgeons. Additionally, it is possible that pediatric orthopaedic surgeons are more comfortable working with industry given that disclosure requirements are now transparent. As a result, this may be encouraging newly trained surgeons to take on ties with industry.

Considering sub-types of General payments, from 2014 to 2017, there were significant increases in the median sub-type aggregate payment per surgeon for education and royalty/license. These findings are different from those reported for otolaryngologists from 2014 to 2016: a significant increase in mean payments for speaking fees, food/beverage, honoraria, and travel/lodging payments as well as a decrease in mean payments for education and gift payments. The current
study’s findings may indicate a growing emphasis on education-related expenses in the field of pediatric orthopaedics.

In terms of geographic distribution of compensated pediatric orthopaedic surgeons, the current study found that Midwest pediatric orthopaedic surgeons received the highest median General payment per year.

Relative to General payments, there were fewer Research and Ownership payments to pediatric orthopaedic surgeons during the time frame studied. In fact, Research and Ownership payments comprised 0.07% and 0.2% of total industry payments made to pediatric orthopaedic surgeons from 2014 to 2017, respectively. Though, the total value of Ownership payments did comprise approximately 36% of the total industry (General, Research, and Ownership) payment to pediatric orthopaedists. The current study’s Ownership payment findings are consistent with a study of payments to neurotologic otolaryngologists, which found that 0.3% of payments were ownership-related. The current Research payment findings are similar to a study in neurosurgery (0.2% of payments) and different from a study in neurotologic otolaryngology (43%). Different research foci, research funding sources, and industry goals may account for this difference.

Although a number of interesting observations are made by the current study, there are several limitations. First, OPD data is self-reported by industry. Moreover, as there is no self-corrective algorithm in place to confirm validity of payments, the accuracy of the data reported in terms of monetary amount or physician specialty can be questioned. Nonetheless, this is the data reported
to and seen by the public. Second, the current study does not evaluate trends in single-surgeon payments over time. It was thought that this was too specific in nature for this overview analysis. Third, the current study focuses only on payments to physicians, and does not relate industry payment to surgeons’ practice patterns. This is a more challenging analysis and causality is not as clearly defined.

Nonetheless, the current study examines trends in General industry payments to pediatric orthopaedic surgeons over the years 2014 to 2017 using the publicly available OPD. Over this four-year period, the current study found an increase in the number of pediatric orthopaedic surgeons receiving General industry payments, but no increase in the median payment surgeons received. However, when considering the top 5% of compensated surgeons, who receive between 62 and 82% of total General dollar payments, the analysis identifies that the amount received more than doubled between 2014 and 2017.

Many expected payments to surgeons to decrease when put under the public scrutiny of the OPD. Not only was this decrease not observed for General payments to pediatric orthopaedic surgeons from 2014 to 2017, but the median payments to the top 5% increased.
Figure 1: General payments to pediatric orthopaedic surgeons by percentile and year are shown. Figure 1A shows all compensated surgeons. Figure 1B focuses on the upper range of compensated surgeons (x-axis focused to upper range).
Figure 2: Boxplot of General payments per compensated pediatric orthopaedic surgeon by year is shown. Figure 2A shows data for the top 5% of compensated pediatric surgeons. Figure 2B shows data for remaining 95% of compensated surgeons. Median payments in 2015, 2016, and 2017 were compared to those in 2014 (with significant changes starred).
Figure 3: Percent change in median General aggregate payment per surgeon for each sub-type comparing 2014 payments to 2017 payments is shown (significant increases in median payment starred and shaded in darker color). Percent changes for sub-types with zero surgeons receiving General payments in 2014 were not included in this figure.
Figure 4: Median General payments (listed as 2014, 2015, 2016, 2017) per compensated pediatric orthopaedic surgeon for each U.S. census region are shown. Across all census regions, comparing median General payments in 2015, 2016, and 2017 to those in 2014 showed no significant change (p>0.05).
<table>
<thead>
<tr>
<th>Year</th>
<th>All Pediatric Orthopaedic Surgeons</th>
<th>Top 5% Compensated</th>
<th>Remaining 95% Compensated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of surgeons, n</td>
<td>Median Payment (IQR) ($)</td>
<td>P-Value (vs 2014)</td>
</tr>
<tr>
<td>2014</td>
<td>324</td>
<td>201 (1313)</td>
<td>-</td>
</tr>
<tr>
<td>2015</td>
<td>336</td>
<td>234 (1100)</td>
<td>0.532</td>
</tr>
<tr>
<td>2016</td>
<td>353</td>
<td>283 (1729)</td>
<td>0.167</td>
</tr>
<tr>
<td>2017</td>
<td>429</td>
<td>197 (1247)</td>
<td>0.82</td>
</tr>
</tbody>
</table>

*aGeneral payments only
bIQR: interquartile range
<table>
<thead>
<tr>
<th>Sub-Type</th>
<th>Pediatric Orthopaedic Surgeons, n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2014</td>
</tr>
<tr>
<td>Education</td>
<td>25</td>
</tr>
<tr>
<td>Royalty/License</td>
<td>12</td>
</tr>
<tr>
<td>Consulting Fee</td>
<td>25</td>
</tr>
<tr>
<td>Speaker Fees/Serving as Faculty</td>
<td>12</td>
</tr>
<tr>
<td>Honoraria</td>
<td>2</td>
</tr>
<tr>
<td>Food/Beverage</td>
<td>304</td>
</tr>
<tr>
<td>Travel/Lodging</td>
<td>94</td>
</tr>
<tr>
<td>Gift</td>
<td>5</td>
</tr>
<tr>
<td>Grant</td>
<td>5</td>
</tr>
<tr>
<td>Charitable Contribution</td>
<td>0</td>
</tr>
<tr>
<td>Ownership or Investment</td>
<td>0</td>
</tr>
<tr>
<td>Entertainment</td>
<td>0</td>
</tr>
</tbody>
</table>
## Table 2B. Median Sub-Type Aggregate Payment per Surgeon and Year

<table>
<thead>
<tr>
<th>Sub-Type</th>
<th>Median Aggregate Payment (IQRa) ($)</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>255 (1020)</td>
<td>401 (830)</td>
<td>415 (1838)</td>
<td>1615 (2720)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Royalty/License</td>
<td>10,847 (14,618)</td>
<td>17,518 (21,624)</td>
<td>13,734 (32,984)</td>
<td>27,828 (100,890)</td>
<td>0.031</td>
<td></td>
</tr>
<tr>
<td>Consulting Fee</td>
<td>2500 (10,040)</td>
<td>4625 (13,563)</td>
<td>5252 (9875)</td>
<td>6364 (11,001)</td>
<td>0.145</td>
<td></td>
</tr>
<tr>
<td>Speaker Fees/Serving as Faculty</td>
<td>3336 (4078)</td>
<td>2838 (21,624)</td>
<td>1500 (2455)</td>
<td>4900 (7433)</td>
<td>0.113</td>
<td></td>
</tr>
<tr>
<td>Honoraria</td>
<td>2025 (1475)</td>
<td>2000 (9369)</td>
<td>3150 (2700)</td>
<td>2000 (1500)</td>
<td>0.613</td>
<td></td>
</tr>
<tr>
<td>Food/Beverage</td>
<td>137 (234)</td>
<td>149 (255)</td>
<td>152 (340)</td>
<td>129 (243)</td>
<td>0.735</td>
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<tr>
<td>Travel/Lodging</td>
<td>1058 (1246)</td>
<td>824 (1034)</td>
<td>891 (1132)</td>
<td>772 (1037)</td>
<td>0.01</td>
<td></td>
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<tr>
<td>Gift</td>
<td>56 (8)</td>
<td>-</td>
<td>352 (4379)</td>
<td>34 (0)</td>
<td>0.38</td>
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</tr>
<tr>
<td>Grant</td>
<td>8333 (5722)</td>
<td>8063 (9369)</td>
<td>6500 (8738)</td>
<td>1000 (0)</td>
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<tr>
<td>Charitable Contribution</td>
<td>-</td>
<td>49 (0)</td>
<td>68 (71)</td>
<td>55 (1)</td>
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<tr>
<td>Ownership or Investment</td>
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<td>2194 (2092)</td>
<td>-</td>
<td>4600 (0)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Entertainment</td>
<td>-</td>
<td>31 (6)</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

aIQR: interquartile range
bP-Values are comparing 2014 medians to 2017 medians.
### Table 3. Number of Compensated Pediatric Orthopaedic Surgeons and Median Payment by U.S. Census Region and Year

<table>
<thead>
<tr>
<th>Census Region</th>
<th>n(^a)</th>
<th>2014 Median Payment (IQR)b</th>
<th>n</th>
<th>2015 Median Payment (IQR)</th>
<th>n</th>
<th>2016 Median Payment (IQR)</th>
<th>n</th>
<th>2017 Median Payment (IQR)</th>
<th>P-Value(^c)</th>
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</thead>
<tbody>
<tr>
<td>Midwest</td>
<td>53</td>
<td>209 (1261)</td>
<td>48</td>
<td>479 (2149)</td>
<td>48</td>
<td>402 (3024)</td>
<td>75</td>
<td>292 (1339)</td>
<td>0.337</td>
</tr>
<tr>
<td>Northeast</td>
<td>50</td>
<td>125 (238)</td>
<td>60</td>
<td>177 (767)</td>
<td>64</td>
<td>130 (704)</td>
<td>72</td>
<td>104 (632)</td>
<td>0.775</td>
</tr>
<tr>
<td>South</td>
<td>160</td>
<td>208 (1344)</td>
<td>162</td>
<td>236 (935)</td>
<td>173</td>
<td>305 (1410)</td>
<td>207</td>
<td>195 (1839)</td>
<td>0.99</td>
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<tr>
<td>West</td>
<td>59</td>
<td>186 (1527)</td>
<td>64</td>
<td>198 (1217)</td>
<td>66</td>
<td>319 (3338)</td>
<td>83</td>
<td>197 (1534)</td>
<td>0.945</td>
</tr>
</tbody>
</table>

\(^{a}\) 'n' represents number of compensated pediatric orthopaedic surgeons  
\(^{b}\) 'Median Payment (IQR)' is represented in U.S. dollars  
\(^{c}\) P-value represents comparisons between 2014 and 2017 medians
Chapter 2:

Assessment of Industry Payments to Orthopaedic Foot and Ankle Surgeons

This chapter was published as follows:

Pathak N, Galivanche AR, Lukasiewicz AM, Mets EJ, Mercier MR, Bovonratwet P, Walls RJ, Grauer JN. Orthopaedic Foot and Ankle Surgery Industry Compensation Reported by the Open Payments Database. *Foot and Ankle Specialist* (Accepted 12/19).
Abstract:

Background:
The Open Payments Database (OPD) is a listing of payments from industry to physicians that classifies payments into General, Ownership, or Research categories. The current study aims to characterize and explore trends in OPD payments reported to orthopaedic foot and ankle (F&A) surgeons over time.

Methods:
For the years 2014-2017, General, Ownership, and Research payments to compensated orthopaedic F&A surgeons were characterized by overall total payment sum and number of transactions. The total payment was compared by category. Payments per surgeon were also assessed. Median payments for all orthopaedic F&A surgeons and the top 5% compensated were then calculated and compared across the years. The number and median payments per U.S. census region were calculated and compared. Medians were compared through Mann-Whitney U tests.

Results:
Over the period assessed, industry paid over $39 million through 29,442 transactions to 802 compensated orthopaedic F&A surgeons. The majority of this payment was classified as General (64%), followed by Ownership (34%), and Research (2%). The median annual payments per orthopaedic F&A surgeon were compared to the 2014 median ($616): 2015 ($505; p=0.191), 2016 ($868; p=0.088), and 2017 ($336; p=0.084). Over these years, the annual number of compensated orthopaedic F&A surgeons increased from 490 to 556. Averaged over four years,
91% of the total orthopaedic F&A payment was made to the top 5% of orthopaedic F&A surgeons. The median payment for this group increased from $177K (2014) to $192K (2017; p=0.012). Regional analyses were also performed.

**Conclusion:**

Though median payments to the top 5% of compensated orthopaedic F&A surgeons increased, there was no overall change in median payment over four years for all compensated orthopaedic F&A surgeons. These findings shed insight into the orthopaedic F&A surgeon-industry relationship in the current age of increased transparency.
**Introduction:**

The relationships between physicians and industry have been an area of discussion. These relationships allow for exchange of information and collaboration on innovation, but may also lead to biases that could affect patient care.\textsuperscript{1,2} Nonetheless, the widespread nature of such relationships is highlighted by a 2015 survey of 3167 physicians in six specialties that showed that 94\% of those surveyed had some relationship with industry.\textsuperscript{5}

To mitigate the potential for conflict of interest, in 2010, Congress enacted the Physician Payments Sunshine Act (“Sunshine Act”) in an attempt to make the relationships between physicians and industry clear and transparent to the public.\textsuperscript{6} This law included the creation of the Open Payment Database (OPD) to collect and present this data. The OPD serves as a public listing of all payments of greater than ten dollars made to physicians.\textsuperscript{6} The data are submitted to the Centers for Medicare and Medicaid Services (CMS) by all drug and devices manufacturers. Publicly disclosed data from the OPD now includes the last half of 2013, and the entirety of 2014 through 2017.

The OPD contains data about all types of payments to physicians from industry, which are broadly categorized as General (for food/beverage, consulting, etc.), Research (for research grants or contracts), or Ownership (for ownership stake in a company). For the most recent year of OPD data available (2017), 94.6\% of the total industry payment value to all physicians was considered General, 5.3\% was considered Research, and 0.1\% was considered Ownership.\textsuperscript{33}
The OPD data have been examined generally and within many sub-specialties since their release. In orthopaedic surgery, the first year of OPD data (2013) were analyzed in three studies. Overall, these studies found that, although most surgeons have a relationship with industry, in most cases the financial payment was small, and a small proportion of surgeons received the majority of industry dollars. Another study found that disclosures at the American Academy of Orthopaedic Surgeons Annual Meeting in 2014 did not match OPD data 35% of the time.

In other disciplines, more recent data from the OPD have been analyzed to look at trends over time. For instance, in Urology, it was found that the number of surgeons with industry relationships stayed similar, but total payments went down between 2014 and 2016. Additionally, an evaluation of the OPD in plastic surgery showed a decrease in the number of plastic surgeons holding industry ties and a reduction in total payment from 2013 to 2014. It has been hypothesized that increased public scrutiny afforded by the OPD was at least in part responsible for the reported trend.

While the pattern of payments in orthopaedic surgery as whole has been studied, the patterns and trends in payments to orthopaedic foot and ankle (F&A) surgeons in particular had not been previously assessed. The current study aimed to address these gaps by quantifying and characterizing industry payments to compensated orthopaedic F&A surgeons over time. It was hypothesized payments to orthopaedic F&A surgeons would decrease over the study period.
Methods:

*Overall Payment Data*

The General Payments, Ownership Payments, and Research Payments datasets were downloaded and compiled from the CMS OPD website for 2014 to 2017. The subset of data for orthopaedic F&A surgeons was then extracted utilizing the OPD physician sub-specialty information, which is reported by industry. The current study was considered exempt from Human Institutional Review Board review at our institution.

For the study period, overall and category-specific payments were calculated by year and in aggregate. The number of payment transactions was also assessed.

*Surgeon-Specific Data*

All General, Ownership, and Research payments attributed to each orthopaedic F&A surgeon in the OPD were summed for each year. Subsequently, this allowed calculation of the median annual industry payment per orthopaedic F&A surgeon for 2014-2017. Median data in 2014 was used as the reference to which 2015, 2016, and 2017 data were compared. Due to the nonparametric nature of the data (Shapiro-Wilk test: p<0.001), comparisons between the years were made through Mann-Whitney U tests.
Acknowledging the skewed distribution of the data, in addition to overall comparisons, the top 5% of compensated orthopaedic F&A surgeons were additionally compared across the years. These comparisons were similarly made with Mann-Whitney U tests.

Geographic Distribution of Payments

As practice location data is available for each physician in the OPD, the state of each compensated orthopaedic F&A surgeon in the database was available and assigned to one of four U.S. census regions: Northeast, Midwest, South, West. This facilitated calculation of the median annual industry payment (General, Ownership, and Research included) per surgeon for each census region and year.

Finally, the median annual payment per surgeon for each census region in 2014 was compared to its equivalent in 2017 in a nonparametric fashion to assess geographic temporal net changes across this time period.

Data Analysis

Statistical analyses were performed using Stata version 13.0 (StataCorp LLC, College Station, TX) and Microsoft Excel. Statistical significance was established at p < 0.05. Figures were constructed using GraphPad Prism.
Results:

*Overall Payment Data*

From 2014 to 2017, a total payment sum of $38,689,056 was made to 802 reported orthopaedic F&A surgeons through 29,442 industry transactions (General, Ownership, and Research included) (Table 1).

The majority of total orthopaedic F&A industry dollars were classified as General ($24,880,513; 64%), followed by Ownership ($13,056,500; 34%), and Research ($752,043; 2%) (Figure 1).

*Surgeon-Specific Data*

In 2014, the median value of the annual sums of industry payments (General, Ownership, and Research included) attributed to each compensated orthopaedic F&A surgeon was $616 (Figure 2). Comparing later years to 2014, the median annual industry payment per compensated orthopaedic F&A surgeon showed no net change: 2015 (median $505; p=0.191), 2016 (median $868; p=0.088), 2017 (median $336; p=0.084).

Payments to orthopaedic F&A surgeons were concentrated among the surgeons who received the top 5% of compensation (Figure 3). The top 5% of compensated orthopaedic F&A surgeons received 91% of the total orthopaedic F&A surgeon industry compensation, when averaged over four years. Thus, subsequent analysis of the top 5% of compensated orthopaedic F&A surgeons
was performed and revealed that, compared to 2014 (median $177,030) there had been an increase in 2016 (median $196,267, p=0.007) and 2017 (median $192,115, p=0.012).

Over the years, the number of compensated orthopaedic F&A surgeons increased from 490 to 556. All median payment data and number of compensated orthopaedic F&A surgeons by year are given in Table 2.

**Geographic Distribution of Payments**

The number of compensated orthopaedic F&A surgeons receiving industry payments (General, Ownership, and/or Research) in each U.S. census region is shown in Table 3A. The highest number of compensated orthopaedic F&A surgeons was in the South, followed by the West for each of the years studied.

By year, the census region exhibiting the highest median industry payment per compensated orthopaedic F&A surgeon was the Northeast (in 2014 and 2015) and the Midwest (in 2016 and 2017) (Table 3B). A change in median payment from 2014 to 2017 was noted only in the Northeast census region (p=0.048).
Discussion:

Orthopaedic surgeons have long maintained close relationships with industry, perhaps because of the importance of implants and surgical tools to orthopaedic procedures. Previous studies have assessed OPD payments in the fields of otolaryngology, neurosurgery, plastic surgery, and cardiothoracic surgery.\textsuperscript{9,14-16,28,30,35}

In the field of orthopaedic surgery, past studies have looked at the specialty as a whole and have summarized OPD data over short time spans.\textsuperscript{8,17,18} With the passage of the Physician Payments Sunshine Act in 2013, many expected the heightened public scrutiny on industry payments to decrease the magnitude of such relationships.\textsuperscript{2,6,25} In fact, this trend was observed in the fields of plastic surgery and urology.\textsuperscript{15,21} To the best of the authors’ knowledge, the current study was the first to use the OPD to examine how industry payments to orthopaedic F&A surgeons have changed from the initial full calendar-year release of OPD data (2014) to 2017.

The current study first assessed orthopaedic F&A payments overall, and found that a total of 802 orthopaedic F&A surgeons received a sum of $38,689,056 in industry compensation (General, Ownership, and Research included) from 2014-2017. The majority of total industry dollars in F&A orthopaedics was classified as General (64%), followed by Ownership (34%) and Research (2%). This distribution by category was found to be similar to other sub-specialties in orthopaedic surgery such as pediatric orthopaedics.\textsuperscript{20} However, this distribution was different from payments overall in the OPD, in which greater than 94% of the total industry payment value was classified as General.\textsuperscript{33}
Subsequent analysis found no overall change in median annual industry payment per compensated orthopaedic F&A surgeon from 2014 to 2017 (p=0.084). This finding is contrary to the findings reported in urology and plastic surgery and contrary to the hypothesis of the current study.15,21 That said, this finding is similar to results reported in otolaryngology, oral/maxillofacial surgery, and pediatric orthopaedic surgery.15,21,36 With the above said, the majority of total orthopaedic F&A industry dollars were made to the top 5% of compensated orthopaedic F&A surgeons. When considering this sub-group of surgeons by year, there was a significant increase in median payment over the four-year period. This observed trend was opposite to the current study’s hypothesis.

Over the time period studied, the number of compensated orthopaedic F&A surgeons per year increased (490 to 556). It is possible that the increased regulation of disclosure policies and public awareness brought on by the Sunshine Act may have led to an increase in the number of companies reporting payments to orthopaedic F&A surgeons. This finding was also contrary to the current study’s hypothesis.

For geographic analyses, there were changes observed in median annual industry payment per compensated orthopaedic F&A surgeon for the Northeast census region. Surgeons in the Northeast also had the highest median payment in 2014, whereas surgeons in the Midwest had the highest median payment in 2017. The current findings slightly differ from results in pediatric orthopaedic surgery, a field in which surgeons in the Midwest received the highest median
payment throughout all four years. Differences in compensation across census regions may indicate regional preferences for certain pharmaceutical or device manufacturers.

Overall, the current study focused on compensated orthopaedic F&A surgeons. The findings align with some but not all prior reports from other fields. Some of the differences may be attributed to differences in these relationships between specialties (use of implants, etc.). There may also be differing attitudes towards industry relationships.

There are limitations to the current study. Foremost, data is reported by industry, and it is possible that there are inaccuracies in monetary amount or physician specialty designation in the OPD data. Nonetheless, there is the opportunity for surgeons to address concerns with the data and, further, this is the data visible to and interpreted by the public. Second, the study does not track trends for individual surgeons, as this was thought to be overly granular for the current high-level analysis. Finally, the denominator was not available for the current analyses (i.e. the total number of practicing orthopaedic F&A surgeons) for each year.

No prior studies have specifically characterized or examined temporal trends in financial relationships between industry and orthopaedic F&A surgeons. The current study analyzes payments to orthopaedic F&A surgeons using four full years of available data in the OPD. Despite the median annual payment increasing for the top 5% of compensated orthopaedic F&A surgeons, median annual payments per orthopaedic F&A surgeon overall remained stable since 2014. These findings shed insight into the orthopaedic F&A surgeon-industry relationship in the current age of greater transparency.
Figure 1: Pie chart depicting percentage of total orthopaedic F&A industry dollars (2014-2017) by category: General (64%), Ownership (34%), Research (2%).
Figure 2: Boxplot of industry payments (General, Ownership, and Research included) per compensated orthopaedic F&A surgeon by year. The lines on each box represent the 25th, 50th (median), and 75th percentile (spread of interquartile range). A Y-axis break is in place to allow visualization of the interquartile range and the maximum/minimum values. 2015-2017 median payments were compared to the 2014 median payment (with significant changes in median payment starred).
Figure 3: Industry payments (General, Ownership, and Research included) per orthopaedic F&A surgeon by percentile and year. In Figure 1A all compensated orthopaedic F&A surgeons are represented, which shows the majority of industry dollars are made to the top few percent compensated. Figure 1B, therefore, has an x-axis break in place to allow visualization of the top compensated orthopaedic F&A surgeons by year.
<table>
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<tr>
<th>Year(s)</th>
<th>General</th>
<th>Ownership</th>
<th>Research</th>
<th>All Categories</th>
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<tbody>
<tr>
<td></td>
<td>Payment Sum ($)</td>
<td>Number of Transactions (n)</td>
<td>Payment Sum ($)</td>
<td>Number of Transactions (n)</td>
</tr>
<tr>
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<td>6,593,669</td>
<td>6980</td>
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<tr>
<td>2015</td>
<td>5,990,176</td>
<td>7610</td>
<td>4,459,875</td>
<td>24</td>
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<tr>
<td>2016</td>
<td>6,783,504</td>
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<td>2,513,325</td>
<td>22</td>
</tr>
<tr>
<td>2017</td>
<td>5,513,164</td>
<td>6120</td>
<td>3,782,051</td>
<td>27</td>
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<td>2014-2017</td>
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<td>28,974</td>
<td>13,056,500</td>
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<td>9,322,450</td>
<td>6150</td>
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<td>Year</td>
<td>All Compensated F&amp;A Surgeons</td>
<td>Top 5% Compensated F&amp;A Surgeons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------</td>
<td>---------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of Surgeons (n)</td>
<td>Median Payment (IQR*) ($)</td>
<td>P-Value (vs 2014)</td>
<td>Median Payment (IQR*) ($)</td>
</tr>
<tr>
<td>2014</td>
<td>490</td>
<td>616 (4042)</td>
<td>-</td>
<td>177,030 (155,416)</td>
</tr>
<tr>
<td>2015</td>
<td>567</td>
<td>505 (3279)</td>
<td>0.191</td>
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</tr>
<tr>
<td>2016</td>
<td>510</td>
<td>868 (4042)</td>
<td>0.088</td>
<td>196,267 (248,748)</td>
</tr>
<tr>
<td>2017</td>
<td>556</td>
<td>336 (3924)</td>
<td>0.084</td>
<td>192,115 (237,670)</td>
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*IQR: Interquartile range*
<table>
<thead>
<tr>
<th>U.S. Census Region</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
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</thead>
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<td>104</td>
<td>112</td>
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<td>South</td>
<td>177</td>
<td>211</td>
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<tr>
<td>U.S. Census Region</td>
<td>2014</td>
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<tr>
<td>-------------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Midwest</td>
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<tr>
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<td>896 (3734)</td>
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<tr>
<td>West</td>
<td>589 (2777)</td>
<td>556 (2432)</td>
<td>762 (4025)</td>
<td>479 (4698)</td>
</tr>
</tbody>
</table>

¹P-values represent comparisons between 2014 medians and 2017 medians.
²IQR: Interquartile range.
Chapter 3:

Assessment of Industry Payments to Orthopaedic Spine Surgeons

This chapter is under editorial review in a peer-reviewed publication as follows:

Abstract:

**Study Design:** This was a retrospective study of publicly available data.

**Objective:** To characterize and assess trends in Open Payments Database (OPD) industry payments reported to orthopaedic spine surgeons from 2014 to 2017.

**Summary of Background Data:** There have been a lack of studies characterizing OPD industry payments to orthopaedic spine surgeons over the four full years of data available.

**Methods:** General industry payments made to orthopaedic spine surgeons from 2014 to 2017 were characterized by year with analysis of: number of compensated surgeons, median payment per surgeon, top strata of compensated surgeons, and sub-type (i.e. food/beverage). Research and Ownership payments were characterized by median payment per surgeon. Mann-Whitney U tests were used to compare payments.

**Results:** For General payments, the number of compensated orthopaedic spine surgeons increased from 1539 in 2014 to 1673 in 2017. Later year median General payments per surgeon were compared to the 2014 median ($1051): 2015 ($1070: p=0.375), 2016 ($1263: p=0.012), and 2017 ($978: p=0.561). In 2014, the top 10% of compensated orthopaedic spine surgeons received 89% of the total General compensation to orthopaedic spine surgeons, top 5% received 79%, and the top 1% received 55%. The median General payment for these three top strata remained similar over the four years evaluated (p>0.05). For sub-type analyses, the median aggregate General payment for ‘education’ increased (p=0.002) across the years. Finally, it was determined that the median payment per surgeon for Research and Ownership payment categories remained stable across the time period (p>0.05).

**Conclusions:** Many expected industry payments to surgeons to decrease under public scrutiny of the OPD, but the present study showed no net change in median payment (General, Research,
and Ownership) over the years studied. In the age of greater transparency, these findings shed insight into the orthopaedic spine surgeon-industry relationship.
Introduction

To increase physician-industry relationship transparency, lawmakers enacted the Physician Payments Sunshine Act and the Open Payments Database (OPD). This law requires manufacturers to submit data to the Centers for Medicare and Medicaid Services (CMS) regarding transfers to physicians greater than $10 in value.

The OPD has publicly released five sets of data: the last five months of 2013, and the full years of 2014, 2015, 2016, and 2017. Data is grouped into three datasets: General Payments, Research Payments, and Ownership Payments. General Payments include payments for activities such as consulting. The Research Payments dataset includes payments made in association with defined research agreements. The Ownership Payments dataset includes payments related to direct ownership.

Some physicians cast skepticism on the accuracy of OPD. Additionally, some hold the viewpoint that there is a possible risk for misinterpretation due to lack of appropriate context for payment entries. Nonetheless, the OPD remains the largest and most comprehensive tracking platform of physician-industry relationships available to the public.

In the field of orthopaedic surgery, three studies have described and characterized industry payments using the initial 2013 release of the OPD. Specific to spine surgeons, a study used 2013 and 2014 OPD data to find that factors such as length of orthopedic training and academic practice setting were significantly associated with spine surgeons engaging in industry
relationships. However, no studies have examined spine surgeon-specific payments from more recent years in this database.

Greater awareness of public reporting from the OPD may discourage physicians or industry from engaging in relationships. This was observed in plastic surgery, in which an evaluation of the OPD showed a decrease in total industry dollars and the number of plastic surgeons holding industry ties from 2013 to 2014.

With growing attention being given to the topic of physician-industry relationships, the present study aims to investigate trends in payments to orthopaedic spine surgeons reported by the OPD over the four full years of available data (2014 to 2017). It was hypothesized that the number of compensated orthopaedic spine surgeons, as well as the median value of payments made to orthopaedic spine surgeons, would decrease from 2014 to 2017.
Methods:

Study Population and Payment Data
The OPD General Payments, Research Payments, and Ownership Payments datasets were downloaded for the years of 2014 to 2017 from the CMS OPD website. Orthopaedic spine surgeons (identified in the database as those whose specialization was listed as “Orthopaedic Surgery of the Spine”) who received industry compensation were included in the study. Analysis of the publicly available OPD qualified as nonhuman subject research and was deemed exempt from Human Institutional Review Board review at the authors’ institution.

As OPD does not distinguish sub-specialties within neurosurgery (i.e. neurosurgery spine surgery), the present study focused on orthopaedic spine surgeons. Additionally, given that greater than 99% of the number of industry payment transactions made to orthopaedic spine surgeons were classified as General, the present study primarily focused its analyses on General industry payments.

First, total number of General payment transactions and number of compensated orthopaedic spine surgeons were calculated as four-year aggregates (2014-2017). Next, for each year, the number of compensated surgeons, median General payment to each surgeon, and interquartile range (IQR; difference between third and first quartiles) of payments were determined. Also for each year, the median payments for the top 50%, 25%, 10%, 5%, and 1% of compensated orthopaedic spine surgeons were calculated for strata analyses.
The number of orthopaedic spine surgeons receiving a particular sub-type (i.e. food/beverage) of General payment was determined. Next, the median aggregate General payment per surgeon and IQR for each sub-type was then calculated by year. Of note, payments in the following OPD sub-types were summed under the header ‘serving as faculty/speaker fees’ by the authors:

‘compensation for services other than consulting, including serving as faculty or as a speaker at a venue other than a continuing education program,’ ‘compensation for serving as faculty or as a speaker for an accredited or certified continuing education program,’ and ‘compensation for serving as faculty or as a speaker for a non-accredited and noncertified continuing education program.’

The state in which compensated (General payments) orthopaedic spine surgeons practiced was retrieved and used to group surgeons by U.S. census region (Midwest, Northeast, South, and West). The median General payment per surgeon and IQR for each census region was also calculated by year.

For Research and Ownership payment categories, the number of payment transactions, number of compensated orthopaedic spine surgeons receiving such payments, and the median payment per orthopaedic spine surgeon were also determined by year.

**Data Analysis**

For General payments, the median payment per orthopaedic spine surgeon was compared across the four years by using 2014 as the benchmark to which 2015, 2016, and 2017 data were compared. For strata analysis, the median General payments per surgeon for the top 50%, 25%,
10%, 5%, and 1% of compensated orthopaedic spine surgeons in 2014 were compared to their equivalent median payments per strata in 2015, 2016, and 2017; this allowed for trend assessment in the top compensated surgeons. Mann-Whitney U tests were used for such comparisons, given the non-normal distribution of payment data (Shapiro-Wilk test; p<0.001).

The 2014 median aggregate General payment per surgeon for each sub-type was compared to its equivalent in 2017 using the Mann-Whitney U test. Similarly, the 2014 median General payment per surgeon for each census region was compared to its equivalent in 2017 in a similar nonparametric fashion.

For Research and Ownership payment categories, the Mann-Whitney U tests were used to compare 2014 median payments per surgeon to 2017 median payments per surgeon for net change assessment.

Statistical analysis was performed using Stata version 13.0 (StataCorp LLC, College Station, TX) and Microsoft Excel. GraphPad Prism was used to create figures. Statistical significance was established at p < 0.05.
Results:

**General Industry Payments to Orthopaedic Spine Surgeons**

From the General payments dataset, there were 130,012 payments reported to 2175 orthopaedic spine surgeons from 2014 to 2017. The total number of compensated orthopaedic spine surgeons fluctuated by year (Table 1). There was a net increase in the total number of compensated orthopaedic spine surgeons between 2014 to 2017 from 1539 surgeons to 1673 surgeons. Later year median General payments were compared to the median payment of 2014 ($1051): 2015 (median: $1070; p=0.375), 2016 ($1263; p=0.012), and 2017 ($978; p=0.561) (Table 1; Figure 1).

In 2014, the top 50% of compensated orthopaedic spine surgeons received 99.7% of the total General industry compensation; the top 25% received 98%; the top 10% received 89%; the top 5% received 79%; the top 1% received 55% (visually represented in Figure 2). Over the four years studied, there was no net change in median payment per surgeon for each of these five strata (p>0.05).

**General Industry Payments Characterized by Payment Sub-Type**

The number of orthopaedic spine surgeons receiving at least one payment per sub-type is shown in Table 2a. Averaged across the four years studied, the sub-types representing the largest proportion of compensated orthopaedic spine surgeons were ‘food/beverage’ (97%), followed by ‘travel/lodging’ (44%) and ‘consulting fees’ (25%). The following payment sub-types saw a net
increase in the number of surgeons receiving payments from 2014 to 2017: honoraria, royalty/license, travel/lodging, food/beverage, and grant (approximately half of the sub-types).

Median aggregate General payments per surgeon for each sub-type are shown in Table 2b. A significant net increase in median payment from 2014 to 2017 was observed in the ‘education’ ($35 vs. $83; p=0.002) sub-type. A significant net decrease in median payment from 2014 to 2017 was observed in the ‘grant’ ($18,250 vs. $2,750; p=0.04) sub-type. Figure 3 illustrates percent changes (2014 vs 2017) in median sub-type aggregate payment per surgeon.

**General Industry Payments Characterized by Census Region**

The number of compensated orthopaedic spine surgeons receiving General payments in each of the U.S. census regions are shown in Table 3. The South had the greatest number of compensated orthopaedic spine surgeons per year, followed by the West.

Median payment values per compensated orthopaedic spine surgeon in each census region are also shown in Table 3. There was no statistically significant trend in median payment per census region when comparing 2014 payments to 2017 payments in any of the geographies. Figure 4 depicts median payment values per surgeon and year within each census region.

**Research and Ownership Payments**

From the Research Payments dataset, there were few payments reported (n=477) to 119 orthopaedic spine surgeons from 2014 to 2017. Over time, the number of payments made
remained relatively similar from 2014 to 2017: 89, 178, 114, 95. When comparing the 2014 Research payment median ($6017) to the Research payment medians from 2015 ($2244; p=0.023), 2016 ($4850; p=0.732), and 2017 ($5295; p=0.995), there was no net change found across the years despite some fluctuation.

From the Ownership Payments dataset, there were few payments reported (n=637) to 196 orthopaedic spine surgeons from 2014 to 2017. Over time, the number of payments made remained relatively similar from 2014 to 2017: 158, 172, 148, 159. When comparing the 2014 Ownership payment median ($99,997) to the Ownership payment medians from 2015 ($75,000; p=0.306), 2016 ($59,250; p=0.261), and 2017 ($52,152; p=0.222), there were no significant differences found.
Discussion:

Financial relationships are known to exist between physicians and industry. Studies in multiple specialties have suggested that such ties can potentially influence practice patterns. Specifically, it has been suggested that industry-sponsored meals can influence physician prescription patterns of endorsed drugs. Conversely, others have reported that such relationships can be valuable and beneficial when managed in an ethical manner. Public release of industry-physician payment data via the OPD has led to increased transparency.

The advent of the OPD has been generally met with mixed reaction among physicians. Critics argue that the data lacks context, is not readily usable by the average patient, and that industry payments do not typically affect clinical decision making. Indeed, it has been shown that few patients are aware of their physician’s industry ties and are unaware that payment information is publicly available.

Prior studies using the OPD have demonstrated significant variability in the amounts and types of industry payments made to surgeons across different specialties. Among these, orthopaedic surgery has been highlighted as having one of the highest industry payment amounts. Limited research examining industry payments to orthopaedic spine surgeons, in particular, exists. The present study is the first to utilize four years of OPD data to comprehensively evaluate and assess trends in industry payments to orthopaedic spine surgeons.
The present study identified no net change in the median payment amount (for General, Research, and Ownership payments) per orthopaedic spine surgeon from 2014 to 2017. This finding contrasts the hypothesis, though is consistent with a study performed in otolaryngology and pediatric orthopaedic surgery. Additionally, the present study found a net increase in the number of orthopaedic spine surgeons receiving payments from 2014 to 2017, results that directly contrast the hypothesis as well as observations in the field of plastic surgery. These differences can potentially be explained by varying attitudes towards industry ties across different surgical specialties.

In the present study’s cohort, the majority of industry payment dollars were attributed to the top few percent of compensated orthopaedic spine surgeons. Similar disparities in OPD payments have been shown in plastic surgery, neurosurgery, otolaryngology, and cardiothoracic surgery. This may be due to larger payments going to thought leaders or particular surgeons with close industry ties.

It is important to note, however, that the majority of compensated orthopaedic spine surgeons maintain relatively minimal ties with industry in terms of monetary amount; approximately 60% of compensated orthopaedic spine surgeons received less than $2240 in annual General payment, most of which stemmed from food/beverage and travel/lodging payments.

For sub-type analysis, the present study found that while 70% of payment entries were for food/beverage, they accounted for less than 1% of the total dollar amount. This is consistent with the numerous interactions of relatively small financial value that occur between surgeons and
industry. The increase in education payments over the years studied (138%, p=0.002) may suggest a refinement on how industry looks to interact with affiliated surgeons. The decrease in grant payments over the years (85%, p=0.04) may suggest decreasing prioritization of such endeavors sponsored by industry.

When characterizing payments by census region, the south consistently had the highest number of compensated orthopaedic spine surgeons and the west primarily exhibited the highest median payment. These results contrast findings in a separate study, in which neurologists in the northeast had the highest compensated amount.46 In the present study’s cohort, no clear trends in median payments were seen in any of the geographic regions over the four years.

Compared to General payments, Research and Ownership payments only comprised of 0.4% and 0.5% of total industry payment transactions made to orthopaedic spine surgeons, respectively. These Research and Ownership percentages are consistent with investigations in neurosurgery (0.2%) and neurotologic otolaryngology (0.3%), respectively.28,30 Medians for Research and Ownership payments in orthopaedic spine surgeons showed no net change across the years studied (p=0.995 and p=0.222, respectively).

Several limitations exist in this study. First and foremost, some question the accuracy of the OPD data and raise concerns regarding the risk of misinterpretation.6,10,11 As with any database study, the conclusions are subject to the accuracy of the data, but the OPD is the data available to the public. Further, the annual denominator of how many orthopaedic spine surgeons might have received payments was not available from this dataset (in other words, the number of surgeons
receiving no industry payments is not available for analysis by year from this data). Additionally, as noted earlier, neurosurgeons were not included in this present analysis as there is no subcategorization of neurosurgeons in the OPD to identify neurosurgical spine surgeons.

Despite the above-noted limitations, the present study utilizes the largest publicly available database of nationwide financial relationships between physicians and industry to characterize trends in industry relationships among orthopaedic spine surgeons over four years. Many expected industry payments to surgeons to decrease under the public scrutiny of the OPD, but the present study showed no net change in median payment (General, Research, and Ownership) over the years studied. Additionally, a large majority of orthopaedic spine surgeons receive relatively smaller monetary amounts, typically for food/beverage and travel/lodging expenses, while only a select few receive larger amounts. In the age of greater transparency, these findings shed light on the orthopaedic spine surgeon-industry relationship.
**Figure 1:** Boxplot of General payments per compensated orthopaedic spine surgeon by year. The lines on each box represent 25\textsuperscript{th}, 50\textsuperscript{th}, and 75\textsuperscript{th} percentile (interquartile range). A Y-axis break is in place to allow visualization of the interquartile range and the maximum and minimum values. 2015-2017 median payments were compared to the 2014 median payment (with significant changes in median payment starred).
Figure 2: General payments to orthopaedic spine surgeons are represented by year and percentile. In Figure 2A, all spine surgeons are represented, which shows that the majority of industry dollars are made to the top 1% of compensated orthopaedic spine surgeons. Figure 2B, therefore, has an x-axis break in place to allow visualization of the top compensated orthopaedic spine surgeons by year.
Figure 3: Percent change in median aggregate payment per sub-type comparing 2014 payments to 2017 payments (with significant changes in median payment starred and shaded in darker color). Sub-types with fewer than five payments in a year were excluded from this graph.
Figure 4: Median General payment (listed as 2014, 2015, 2016, 2017) per compensated orthopaedic spine surgeon for each U.S. census region. Across all census regions, comparing median General payments in 2015, 2016, and 2017 to those in 2014 showed no significant change (p>0.05).
<table>
<thead>
<tr>
<th>Year</th>
<th>Compensated Orthopaedic Spine Surgeons, n</th>
<th>Median Payment (IQR) ($)</th>
<th>P-Value (Compared to 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1539</td>
<td>1051 (8882)</td>
<td>-</td>
</tr>
<tr>
<td>2015</td>
<td>1532</td>
<td>1070 (9859)</td>
<td>0.375</td>
</tr>
<tr>
<td>2016</td>
<td>1496</td>
<td>1263 (11,194)</td>
<td><strong>0.012</strong></td>
</tr>
<tr>
<td>2017</td>
<td>1673</td>
<td>978 (9310)</td>
<td>0.561</td>
</tr>
</tbody>
</table>
### Table 2A. Number of Orthopaedic Spine Surgeons Receiving At Least One General Payment per Sub-Type and Year

<table>
<thead>
<tr>
<th>Sub-Type</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honoraria</td>
<td>11</td>
<td>64</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Education</td>
<td>131</td>
<td>114</td>
<td>50</td>
<td>56</td>
</tr>
<tr>
<td>Serving as Faculty/Speaker Fees</td>
<td>149</td>
<td>108</td>
<td>111</td>
<td>137</td>
</tr>
<tr>
<td>Royalty/License</td>
<td>234</td>
<td>269</td>
<td>285</td>
<td>294</td>
</tr>
<tr>
<td>Consulting Fee</td>
<td>401</td>
<td>396</td>
<td>377</td>
<td>384</td>
</tr>
<tr>
<td>Travel/Lodging</td>
<td>692</td>
<td>676</td>
<td>677</td>
<td>693</td>
</tr>
<tr>
<td>Food/Beverage</td>
<td>1496</td>
<td>1483</td>
<td>1432</td>
<td>1622</td>
</tr>
<tr>
<td>Grant</td>
<td>8</td>
<td>3</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Charitable Contribution</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Entertainment</td>
<td>17</td>
<td>23</td>
<td>49</td>
<td>11</td>
</tr>
<tr>
<td>Gift</td>
<td>53</td>
<td>80</td>
<td>70</td>
<td>2</td>
</tr>
<tr>
<td>Investment/Ownership Interest</td>
<td>25</td>
<td>12</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Honoraria</td>
<td></td>
<td>1000 (4375)</td>
<td>50 (25)</td>
<td>1616 (4000)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td>35 (180)</td>
<td>60 (201)</td>
<td>144 (417)</td>
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<td>Serving as Faculty/Speaker Fees</td>
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<td>7000 (15,220)</td>
<td>8500 (15,509)</td>
<td>7110 (12,292)</td>
</tr>
<tr>
<td>Royalty/License</td>
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<td>30,2001 (99,636)</td>
<td>28,042 (95,976)</td>
<td>33,285 (107,573)</td>
</tr>
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<td>Consulting Fee</td>
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<td>10,118 (23,463)</td>
<td>11,510 (22,963)</td>
<td>10,400 (21,744)</td>
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<tr>
<td>Travel/Lodging</td>
<td></td>
<td>1414 (2463)</td>
<td>1418 (2448)</td>
<td>1336 (2324)</td>
</tr>
<tr>
<td>Food/Beverage</td>
<td></td>
<td>314 (706)</td>
<td>345 (729)</td>
<td>362 (788)</td>
</tr>
<tr>
<td>Grant</td>
<td></td>
<td>18,250 (52,001)</td>
<td>20,000 (17,083)</td>
<td>222 (7286)</td>
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<tr>
<td>Charitable Contribution</td>
<td></td>
<td>10,000 (14,500)</td>
<td>17,130 (41,748)</td>
<td>30,247 (63,530)</td>
</tr>
<tr>
<td>Entertainment</td>
<td></td>
<td>77 (108)</td>
<td>82 (254)</td>
<td>116 (143)</td>
</tr>
<tr>
<td>Gift</td>
<td></td>
<td>46 (46)</td>
<td>46 (47)</td>
<td>140 (0)</td>
</tr>
<tr>
<td>Investment/Ownership</td>
<td></td>
<td>12,308 (143,541)</td>
<td>101,471 (99,800)</td>
<td>70,224 (95,799)</td>
</tr>
<tr>
<td>Census Region</td>
<td>2014</td>
<td>2015</td>
<td>2016</td>
<td>2017</td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>n&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Median Payment (IQR)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>n</td>
<td>Median Payment (IQR)</td>
</tr>
<tr>
<td>Midwest</td>
<td>287</td>
<td>677 (4952)</td>
<td>283</td>
<td>544 (6347)</td>
</tr>
<tr>
<td>Northeast</td>
<td>266</td>
<td>1401 (8714)</td>
<td>259</td>
<td>725 (13,828)</td>
</tr>
<tr>
<td>South</td>
<td>589</td>
<td>1036 (8226)</td>
<td>585</td>
<td>1128 (7660)</td>
</tr>
<tr>
<td>West</td>
<td>382</td>
<td>1308 (14,811)</td>
<td>394</td>
<td>1508 (18,049)</td>
</tr>
</tbody>
</table>

<sup>a</sup> ‘n’ represents number of compensated orthopaedic spine surgeons

<sup>b</sup> Median Payment (IQR) is in USD

<sup>c</sup> P-values represent comparison between 2014 and 2017 medians
Chapter 4:
Assessment of Industry Payments to Orthopaedic Adult Reconstructive Surgeons

This chapter is under editorial review in a peer-reviewed publication as follows:

Abstract:

**Background:** Open Payments Database (OPD) is a listing of physician-industry payments, categorized as General, Research, or Ownership. The present study characterizes and investigates trends in industry payments to orthopaedic adult reconstructive surgeons from 2014-2017.

**Methods:** All orthopaedic adult reconstructive surgeon payments were characterized by number of transactions and value. General payments were analyzed annually for median payment per surgeon, sub-type, and geography. Research and Ownership payments were analyzed for annual median payments per surgeon. Mann Whitney-U tests were used for comparisons.

**Results:** In total, 60,266 General, Research, and Ownership payments (value of $167M) were reported to orthopaedic adult reconstructive surgeons from 2014-2017. Of this, 96% of the dollars were General ($160M).

For General payments, the number of compensated surgeons increased from 2014 (738) to 2017 (843). Over this period, the median General payment per surgeon remained stable ($774 to $612; p=0.093). However, the inflation-adjusted median payment decreased (p=0.037). Of the General payments, 81% of the dollars were made to the top 5% of compensated surgeons, and the median payment for this stratum remained stable (p>0.05). Median General payment for the education sub-type increased (p=0.003). Median General payment for the Midwest (p=0.044) and West (p=0.004) decreased.
For Research and Ownership categories, median payments (including inflation-adjusted payments) remained stable over the years (p>0.05).

**Conclusion:** The present study shows no change in median General, Research, or Ownership payment per compensated surgeon from 2014-2017, although there was a decrease in inflation-adjusted median General payment. These findings shed light on industry relationships in this field.
Introduction

Passed alongside the Affordable Care Act, the Physician Payment Sunshine Act (PPSA) is a federal law enacted in 2010. It aimed to increase transparency of financial relationships between physician and pharmaceutical/device companies. The ultimate goal of the law was to address potential conflicts of interest for healthcare providers.

Industry relationships can facilitate the exchange of information between physicians and pharmaceutical/device companies. The resulting education, development, and innovation may help advance patient care. With that said, there are also potential biases that can result from such relationships.

The PPSA requires pharmaceutical/device companies report any transfers to physicians in excess of $10. This is done through the Open Payment Database (OPD) which is maintained by the Center for Medicare and Medicaid Services (CMS) and is public, free, and internet accessible. The OPD has released four full years of data (2014-2017), as well as data from the latter part of 2013.

Payment data in the OPD is organized into several broad categories: General, Research, and Ownership. General payments, by far the most common class of payment reported, with subtypes defined (ranging from education to royalties to gifts). Research payments include agreements such as grants for studies/trials or personal payments for scientific writing. Ownership payments
include when a physician has a personal stake in a medical company, such as for dividend or capital gains.

The OPD has been studied in a wide range of medical and surgical fields such as cardiology, interventional radiology, otolaryngology, and plastic surgery. In the orthopaedic literature, investigations have characterized the initial release of OPD data from 2013. One major conclusion from these investigations was that most industry payments are of small monetary value (typically for food/beverage), and that the majority of industry dollars are attributed to a select few surgeons.

Many predicted that making the financial data of the OPD widely accessible would decrease physician/industry relationships. This was, in fact, observed for plastic surgeons. While this has now started to be looked at in other sub-specialties, the patterns of industry payments to orthopaedic adult reconstructive surgeons over time have not been investigated.

The present study aimed to characterize and investigate trends in payments reported by the OPD to adult reconstructive surgeons from 2014 to 2017. The authors hypothesize that the number of compensated orthopaedic adult reconstructive surgeons, as well as the median payment per surgeon, would decrease over this time period.
Methods

Data Abstraction

The OPD General, Research, and Ownership Payment datasets were downloaded for 2014 to 2017 from the CMS OPD website. Surgeons who had received industry compensation and whose specialization was listed as “orthopaedic adult reconstructive surgery” in the database were included in the study. Analysis of the publicly available OPD qualified as nonhuman subject research and was exempt from Human Institutional Review Board review at our institution.

Payment Data

General, Ownership, and Research payments were first collectively examined for all orthopaedic adult reconstructive surgeons in the database for 2014-2017. These data were characterized by summed value and number of transactions.

Given that General payments made up the majority of total payment dollars (96%), General payments to orthopaedic adult reconstructive surgeons were further assessed based on number of surgeons and median payment (and interquartile range; IQR) per surgeon by year. The top 5% of compensated orthopaedic adult reconstructive surgeons were also separately assessed.

The subcategories of General payment were assessed based on the number of surgeons and median/IQR payments. Further, the state of practice for identified surgeons receiving General
payments was determined and used to group surgeons into one of four U.S. census regions (Midwest, Northeast, South, and West). Median/IQR aggregate General payments per census region were also determined by year.

For Research and Ownership payment categories, the median/IQR per compensated orthopaedic adult reconstructive surgeon were also determined by year.

**Statistical Analyses**

The median General payment per surgeon for all compensated orthopaedic adult reconstructive surgeons and the top 5% were analyzed using 2014 as a baseline to which data for the subsequent years were compared. For analysis of net change over the time period with inflation, 2014 payments were adjusted for four years of inflation, and these values were compared to the payments in 2017. The nonparametric Mann-Whitney U Test was used for such comparisons, given the non-normal distribution of payment data (Shapiro-Wilk test: p<0.001).

For General payment sub-type and census region analyses, median General payments per surgeon were compared between 2014 and 2017 payments through Mann-Whitney U tests.

Research and Ownership payment medians per surgeon in 2014 were compared to equivalents in 2015, 2016, and 2017 in a nonparametric fashion. For net change analyses over the four-year period, 2014 Research and Ownership payments were also adjusted for four years of inflation and compared to payments in 2017 using the Mann-Whitney U Test.
Statistical analysis was performed using Stata version 13.0 (StataCorp LLC, College Station, TX) and Microsoft Excel. Figures were created with GraphPad Prism. Statistical significance was defined as $p < 0.05$. 
Results:

Overview of Industry Payments

From 2014 to 2017, a cumulative total of $166,775,467 was made to 1224 orthopaedic adult reconstructive surgeons through 60,226 industry payment transactions (General, Ownership, and Research included) (Table 1). The majority of total orthopaedic adult reconstructive industry dollars were classified as General ($160,103,651; 96%), followed by Ownership ($5,320,433; 3%) and Research ($1,351,383; 1%). Figure 1 graphically depicts total industry dollar breakdown by category.

General Payments per Surgeon

From 2014 to 2017, the number of compensated orthopaedic adult reconstructive surgeons increased from 738 to 843 (Table 2). Payments to orthopaedic adult reconstructive surgeons were concentrated among the surgeons who received the top 5% of compensation (Figure 2). Payments in this stratum represented 81% of total industry dollars in this field (averaged over the years studied).

In 2014, the median value of the annual sums of General industry payments represented by each compensated orthopaedic adult reconstructive surgeon was $774 (Figure 3). Comparing 2015-2017 median payments per surgeon to 2014 data, the median General payment per compensated orthopaedic adult reconstructive surgeon showed no change: 2015 (median $678; p=0.589), 2016
(median $914; p=0.188), and 2017 (median $612; p=0.093) (Figure 3). However, when controlling for inflation, the adjusted median payment in 2014 ($815) showed a significant decrease when compared to the 2017 median payment (p=0.037).

Subsequent analysis of the top 5% of compensated orthopaedic adult reconstructive surgeons was performed. For the top 5% compensated group, the absolute median ($523,406 to $404,795; p=0.509) and inflation-adjusted median (p=0.747) remained stable over time. Absolute median payment data is listed in Table 2.

**General Payments per Sub-Type**

The number of orthopaedic adult reconstructive surgeons receiving at least one General payment per sub-type is shown in Table 3A. Averaged across the four years studied, the sub-types representing the largest proportion of compensated orthopaedic adult reconstructive surgeons were ‘food/beverage’ (97%), followed by ‘travel/lodging’ (46%) and ‘consulting fees’ (23%).

Median General aggregate payments per surgeon for each sub-type are shown in Table 3B. A significant net increase in median payment from 2014 to 2017 was observed in the ‘education’ (p=0.003) sub-type. A significant net decrease in median payment from 2014 to 2017 was observed in the ‘gift’ (p=0.009) sub-type. Percent net changes in median sub-type aggregate payment per surgeon are graphically represented in Figure 4.

**General Payments per Census Region**
The number of compensated orthopaedic adult reconstructive surgeons receiving industry payments (General) in each U.S. census region is shown in Table 4. The highest number of compensated orthopaedic adult reconstructive surgeons was in the South, followed by the West for each year.

The census region showing the highest median General payment per compensated orthopaedic adult reconstructive surgeon varied by year. A change in median payment per surgeon from 2014 to 2017 was noted in the Midwest ($1059 to $490; p=0.044) and West ($1387 to $498; p=0.004).

**Research and Ownership Payments per Surgeon**

From the Research Payments dataset, the median Research payment per compensated orthopaedic adult reconstructive surgeon remained stable when using 2014 ($1625) as the baseline for comparison: 2015 ($1250; p=0.136), 2016 ($1130, p=0.975), and 2017 ($1225, p=0.408). Adjustment for inflation also showed no change in median Research payment over the four-year period (p=0.699).

From the Ownership Payments dataset, the median Ownership payment per compensated orthopaedic adult reconstructive surgeon also remained stable when using 2014 ($25,000) as the baseline for comparison: 2015 ($3416; p=0.096), 2016 ($25,000, p=0.498), and 2017 ($20,000, p=0.637). Adjustment for inflation also showed no change in median Ownership payment over the four-year period (p=0.333).
Discussion:

The relationship between industry and physicians (orthopaedists in particular) has been subject to discussion. While prior studies have evaluated different cohorts from the publicly available OPD, none to our knowledge have specifically looked at industry payments to orthopaedic adult reconstructive surgeons.

Over the years studied (2014-2017), a total of over $166M was paid to orthopaedic adult reconstructive surgeons. The majority of these dollars (96%) were classified as General payments. This skewed distribution does align with the overall numbers in the OPD, in which greater than 94% of the total industry payment value was classified as General. Interestingly, however, some subgroups are not as skewed such as pediatric orthopaedic surgery, in which 64% of payments have been classified as General.

Contrary to the hypothesis, the present study showed an increase in the number of compensated orthopaedic adult reconstructive surgeons and no change in median General payment to this group over the years studied. Of note, however, when adjusting the 2014 General payments for inflation, there was a decrease in median payment per surgeon. The present findings are different from the trend observed in plastic surgery. This difference may be partially explained by varying opinions towards industry relationships by specialty. Consistent with other areas, General payments to orthopaedic adult reconstructive surgeons were skewed such that, over the four years studied, the top 5% of compensated surgeons receiving General payments represented a total of 81% of the cumulative General total.
Classification of the General payment sub-types changed between 2014 and 2017. Industry payments for educational activities increased nearly three-fold since 2014. Industry payments for gifts decreased over time, although the total value was small in every year. Overall, this seems to suggest that, while the median value of payments to orthopaedic adult reconstructive surgeons has not changed, these funds have been directed more towards education. This redirection of funds seems consistent with other fields such as pediatric orthopaedic surgery.

There was substantial variation in median payment between the various census regions each year. The median payment in the West and Midwest dropped over the course of the study period, whereas payments in the Northeast and South did not change significantly. The cause and implication of these results are not clear.

While the Research and Ownership payment categories represented a small percentage of total industry payment dollars in the field, trend analyses were performed. It was found that the median Ownership and median Research payment (including inflation-adjusted payments) remained stable over the years. This is consistent with the trend observed in General payments to orthopaedic adult reconstructive surgeons.

The current study is limited by the weaknesses inherent in OPD. First, orthopaedic adult reconstructive surgeons are identified by industry in the database, but such information, as well as details about practice location and monetary amount, have been questioned. Nevertheless, the OPD is the largest source of industry-physician relationships that is reported to the public.
Second, the OPD contains only surgeons who receive industry payments; surgeons with no financial relationship with industry cannot be studied with this data source.

In summary, over the past four years of increased transparency and disclosure of physician-industry relationships, the proportion of payments to orthopaedic adult reconstructive surgeons devoted to education has significantly increased. However, the median absolute value (General, Ownership, and Research) of industry payments to orthopaedic adult reconstructive surgeons has not significantly changed. Although noted that, when adjusting for inflation, there was a decrease in the General payments to this group. These findings are not intended to provide judgment, but rather to shed light on industry relationships with orthopaedic adult reconstructive surgeons.
Figure 1: Pie chart depicts percentage of total orthopaedic adult reconstructive industry dollars (2014-2017) by category: General (96%), Ownership (3%), Research (1%).
Figure 2: Industry payments (General, Ownership, and Research included) per orthopaedic adult reconstructive surgeon by percentile and year are depicted. In Figure 1A all compensated orthopaedic adult reconstructive surgeons are represented, which shows that the majority of industry dollars are made to the top few percent compensated. Figure 1B, therefore, has an x-axis break in place to allow visualization of the top compensated surgeons by year.
Figure 3.

**General Payments per Compensated Orthopaedic Adult Reconstructive Surgeon by Percentile and Year**

**All Surgeons**

A boxplot showing the distribution of general payments per compensated orthopaedic adult reconstructive surgeon by year. The lines on each box represent the 25th, 50th (median), and 75th percentile, while the entire box represents the interquartile range. A Y-axis break is in place to allow visualization of the interquartile range and the maximum/minimum values. 2015-2017 median payments were compared to the 2014 median payment (no significant changes in median payment were found).

**Focus on Upper Range of Surgeons**

Another boxplot focusing on the upper range of payments for orthopaedic surgeons. The same data visualization principles apply as in the first boxplot.
Figure 4: Percent change in median General aggregate payment per surgeon for each sub-type, comparing 2014 payments to 2017 payments (significant increases in median payments are starred and shaded in dark color). Payments to education increased, while those to gifts decreased.
<table>
<thead>
<tr>
<th>Year(s)</th>
<th>General</th>
<th>Ownership</th>
<th>Research</th>
<th>All Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Payment Sum ($)</td>
<td>Number of Transactions (n)</td>
<td>Payment Sum ($)</td>
<td>Number of Transactions (n)</td>
</tr>
<tr>
<td>2014</td>
<td>35,369,419</td>
<td>14,219</td>
<td>2,291,857</td>
<td>21</td>
</tr>
<tr>
<td>2015</td>
<td>41,403,555</td>
<td>15,265</td>
<td>886,919</td>
<td>16</td>
</tr>
<tr>
<td>2016</td>
<td>48,898,876</td>
<td>15,864</td>
<td>769,098</td>
<td>22</td>
</tr>
<tr>
<td>2017</td>
<td>34,431,801</td>
<td>14,510</td>
<td>1,372,559</td>
<td>21</td>
</tr>
<tr>
<td>2014-2017</td>
<td>160,103,651</td>
<td>59,858</td>
<td>5,320,433</td>
<td>80</td>
</tr>
</tbody>
</table>
Table 2. General Payment Data for All Compensated Orthopaedic Adult Reconstructive Surgeons and Top 5% Compensated

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Compensated Surgeons</th>
<th>Median Payment (IQR) ($)</th>
<th>P-Value (vs 2014)</th>
<th>Median Payment (IQR) ($)</th>
<th>P-Value (vs 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>738</td>
<td>774 (6124)</td>
<td>--</td>
<td>523,406</td>
<td>-</td>
</tr>
<tr>
<td>2015</td>
<td>814</td>
<td>678 (5876)</td>
<td>0.589</td>
<td>497,033</td>
<td>0.606</td>
</tr>
<tr>
<td>2016</td>
<td>782</td>
<td>914 (7427)</td>
<td>0.188</td>
<td>656,800</td>
<td>0.095</td>
</tr>
<tr>
<td>2017</td>
<td>843</td>
<td>612 (3139)</td>
<td>0.093</td>
<td>404,795</td>
<td>0.509</td>
</tr>
</tbody>
</table>
## Table 3A. Number of Orthopaedic Adult Reconstruction Surgeons Receiving At Least One General Payment per Sub-Type and Year

<table>
<thead>
<tr>
<th>Sub-Type</th>
<th>Number of Surgeons, n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2014</td>
</tr>
<tr>
<td>Education</td>
<td>105</td>
</tr>
<tr>
<td>Royalty/License</td>
<td>79</td>
</tr>
<tr>
<td>Consulting Fee</td>
<td>179</td>
</tr>
<tr>
<td>Honoraria</td>
<td>6</td>
</tr>
<tr>
<td>Food/Beverage</td>
<td>707</td>
</tr>
<tr>
<td>Travel/Lodging</td>
<td>356</td>
</tr>
<tr>
<td>Speaker Fees/Serving as Faculty</td>
<td>69</td>
</tr>
<tr>
<td>Gift</td>
<td>5</td>
</tr>
<tr>
<td>Charitable Contribution</td>
<td>0</td>
</tr>
<tr>
<td>Grant</td>
<td>8</td>
</tr>
<tr>
<td>Entertainment</td>
<td>7</td>
</tr>
<tr>
<td>Investment/Ownership</td>
<td>4</td>
</tr>
</tbody>
</table>
# Table 3B. Median Payment (General Payments) Sub-Type Aggregate per Surgeon and Year

<table>
<thead>
<tr>
<th>Sub-Type</th>
<th>Median Payment (IQR) ($)</th>
<th>P-Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>88 (304)</td>
<td>60 (197)</td>
</tr>
<tr>
<td>Royalty/License</td>
<td>57,336 (443,190)</td>
<td>104,444 (446,945)</td>
</tr>
<tr>
<td>Consulting Fee</td>
<td>12,600 (44,750)</td>
<td>12,972 (38,697)</td>
</tr>
<tr>
<td>Honoraria</td>
<td>1800 (1225)</td>
<td>7150 (1975)</td>
</tr>
<tr>
<td>Food/Beverage</td>
<td>303 (712)</td>
<td>261 (670)</td>
</tr>
<tr>
<td>Travel/Lodging</td>
<td>1506 (3198)</td>
<td>1442 (2997)</td>
</tr>
<tr>
<td>Speaker Fees/Serving as Faculty</td>
<td>10,000 (18,200)</td>
<td>5400 (13,842)</td>
</tr>
<tr>
<td>Gift</td>
<td>142 (49)</td>
<td>554 (154)</td>
</tr>
<tr>
<td>Charitable Contribution</td>
<td>-</td>
<td>1250 (0)</td>
</tr>
<tr>
<td>Grant</td>
<td>8503 (12,740)</td>
<td>8060 (0)</td>
</tr>
<tr>
<td>Entertainment</td>
<td>41 (58)</td>
<td>44 (95)</td>
</tr>
<tr>
<td>Investment/Ownership</td>
<td>42,377 (15,242)</td>
<td>202,824 (202,422)</td>
</tr>
</tbody>
</table>

*P-values represent comparisons to 2014 medians of sub-types.
Table 4A. Number of Compensated (General Payment) Orthopedic Adult Reconstruction Surgeons by U.S. Census Region and Year

<table>
<thead>
<tr>
<th>U.S. Census Region</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest</td>
<td>149</td>
<td>162</td>
<td>167</td>
<td>176</td>
</tr>
<tr>
<td>Northeast</td>
<td>158</td>
<td>165</td>
<td>172</td>
<td>187</td>
</tr>
<tr>
<td>South</td>
<td>257</td>
<td>305</td>
<td>262</td>
<td>283</td>
</tr>
<tr>
<td>West</td>
<td>167</td>
<td>174</td>
<td>175</td>
<td>189</td>
</tr>
</tbody>
</table>
Table 4B. Median General Payment per Compensated Orthopaedic Adult Reconstruction Surgeon by U.S. Census Region and Year

<table>
<thead>
<tr>
<th>U.S. Census Region</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>P-Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest</td>
<td>1059 (8705)</td>
<td>1650 (9042)</td>
<td>980 (9010)</td>
<td>490 (2989)</td>
<td>0.044</td>
</tr>
<tr>
<td>Northeast</td>
<td>365 (2493)</td>
<td>591 (7530)</td>
<td>793 (6514)</td>
<td>784 (2464)</td>
<td>0.379</td>
</tr>
<tr>
<td>South</td>
<td>574 (3506)</td>
<td>344 (2773)</td>
<td>940 (4685)</td>
<td>902 (3323)</td>
<td>0.561</td>
</tr>
<tr>
<td>West</td>
<td>1387 (13,064)</td>
<td>1448 (9618)</td>
<td>1113 (17,260)</td>
<td>498 (3895)</td>
<td>0.004</td>
</tr>
</tbody>
</table>

*P-values represent comparisons to 2014 medians of census regions.
Conclusion to Chapters:

This thesis aimed to identify and characterize trends to four different sub-specialties within orthopaedic surgery since the release of the Sunshine Act. The Sunshine Act was released in 2013 by Congress as a means to increase transparency in physician-industry relationships. Prior to work on the current thesis, there had not been any studies in peer-reviewed journals assessing longitudinal trends in industry payments to orthopaedic surgeons.

The present findings show that there has been no change overall in General industry payments to pediatric orthopaedic surgeons, orthopaedic foot and ankle surgeons, orthopaedic spine surgeons, and orthopaedic adult reconstructive surgeons. In two sub-specialties (pediatric orthopaedics and orthopaedic foot and ankle surgery), there was an increase in General payments to the top five percent of compensated surgeons. These findings were contrary to the hypothesis as well as findings in other fields such as plastic surgery. It is possible that these findings shed insight into the impact the Sunshine Act has had on industry relationships. However, additional years of OPD data releases in the future will enable further elucidation of the evolving relationship between industry and orthopaedic surgeons. Further, it is important to note that the present findings do not establish causation. As these findings are largely observational in nature, a limitation to the present study is that there were several additional variables involving industry payments and public awareness that could not be adequately evaluated and controlled for.

Patient education on financial relationships between industry and physicians is important, and reduces the risk of bias in clinical care. Fully disclosing ties to patients as well as government-
sponsored programs spreading awareness about the Open Payments Database may aid in increasing patient knowledge.

Future work will involve assessing payments using the 2018 OPD data release as well as comparing payments between orthopaedic-trained hand surgeons and plastic surgery-trained hand surgeons. In addition to works such as this shedding light on evolving trends in physician industry relationships, they offer a platform to discuss the implications and policies around such interactions.
References:


43. Sharma M, Vadhariya A, Johnson ML, Marcum ZA, Holmes HM. Association between industry payments and prescribing costly medications: an observational study using open payments and medicare part D data. BMC Health Serv Res 2018;18:236.

44. American Orthopaedic Association Orthopaedic Institute of Medicine Task Force on Surgeon-Industry Relationships in the Discipline of Orthopaedic S. Report from the task force on


