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Association between physician characteristics and payments from industry in 2015–2017: observational study

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ABSTRACT

Objective To investigate the association between physician characteristics and the value of industry payments.

Design Observational study.

Setting and participants Using the 2015–2017 Open Payments reports of industry payments linked to the Physician Compare database, we examined the association between physician characteristics (physician sex, years in practice, medical school attended and specialty) and the industry payment value, adjusting for other physician characteristic and institution fixed effects (effectively comparing physicians practicing at the same institution).

Main outcome measures Our primary outcome was the value of total industry payments to physicians including (1) general payments (all forms of payments other than those classified for research purpose, eg, consulting fees, food, beverage), (2) research payments (payments for research endeavours under a written contract or protocol) and (3) ownership interests (eg, stock or stock options, bonds). We also investigated each category of payment separately.

Results Of 544 264 physicians treating Medicare beneficiaries, a total of $5.8 billion in industry payments were made to 365 801 physicians during 2015–2017. The top 5% of physicians, by cumulative payments, accounted for 91% of industry payments. Within the same institution, male physicians, physicians with 21–30 years in practice and physicians who attended top 50 US medical schools (based on the research ranking) received higher industry payments. Across specialties, orthopaedic surgeons, neurosurgeons and endocrinologists received the highest payments. When we investigated individual types of payment, we found that orthopaedic surgeons received the highest general payments; haematologists/oncologists were the most likely to receive research payments and surgeons were the most likely to receive ownership interests compared with other types of physicians.

Conclusions Industry payments to physicians were highly concentrated among a small number of physicians. Male sex, longer length of time in clinical practice, graduated from a top-ranked US medical school and practicing certain specialties, were independently associated with higher industry payments.

Strength and limitations of this study

- The latest and most comprehensive data of the financial relationships between industry and physicians were used by linking a nationally representative Open Payments database with the national database of physicians treating Medicare beneficiaries.
- We examined both the total amount of industry payments to physicians and each category of payment (ie, general payments, research payments and ownership interests), which have not been investigated in prior studies.
- Limitations are the physician database was restricted to physicians treating Medicare beneficiaries and the temporal relationship could not be assessed with the cross-sectional design.

INTRODUCTION

A significant body of research suggests that physicians' financial relationships with industry may influence medical research, education and patient care, including clinical decisions about which medicines to prescribe.[1–11] Concerns about the consequences of physicians' financial conflict of interest and inconsistent disclosure of these conflicts, led to the creation of the Open Payments programme under the *Physician Payment Sunshine Act* (known as the 'Sunshine Act', enacted as part of the Affordable Care Act). The Sunshine Act requires medical product manufacturers and group purchasing organisations (GPOs) to publicly report data on all payments and ownership interests made to licensed physicians (except residents) and teaching hospitals since 2013.[12] The Open Payments database is the most exhaustive and reliable source of data on industry payments to physicians to date.[13–15]

The characteristics of physicians who receive large payments from industry remain incompletely characterised. Several studies have reported that industry payments may

vary substantially based on physicians' sex,[14–17] clinical experience[16 18] and specialty.[10 15 19 20] In addition, a recent study that reported association of physicians' alma mater, medical school ranking and their prescription patterns (for opioids), sheds light on the importance of medical education on physician behaviour, which could potentially impact how industry approach physicians.[21] However, these studies did not adjust for a comprehensive set of physician characteristics, due to lack of the data, and, therefore, it is possible that their findings may be biased if they left out an important physician-level confounder. In other words, it remains unclear whether four important characteristics of physicians—physicians' sex, years in practice, finely categorised specialties and medical school attended—are independently associated with the value of industry payments they receive. Moreover, most prior work on this topic has focused exclusively on non-research payments, despite the fact that some pharmaceutical companies have been using research payments aggressively to influence physicians' prescription of opioid products,[22–24] underscoring the importance of evaluating all forms of payments. Therefore, a better characterisation of physician-level factors associated with higher industry payments—both non-research and research payments from industry—would help to advance our understanding of the financial relationships between industry and practicing US physicians and their potential impact on prescribing patterns and care quality.

In this study, we used a nationally representative database of industry payments to physicians linked with a comprehensive database of physicians treating Medicare beneficiaries, to investigate associations between a broad set of physician characteristics including—sex, years in practice, medical school and clinical specialty—and the value of payments (total amount of industry payments, as well as non-research and research payments separately) received from industry.

METHODS

Data sources

We linked three databases: (1) the 2015–2017 Centers for Medicare and Medicaid Services (CMS) Open Payments database (accessed September 2018), (2) the CMS National Plan & Provider Enumeration System (NPPES) database (accessed September 2018) and (3) the CMS Physician Compare database (accessed January 2019).[25] Data from the 2015–2017 Open Payments programme included data on all general payments, research payments and ownership interests that industry paid physicians in each year. Biomedical companies report payment information to the CMS and physicians are asked to review the information before publication and dispute submitted reports if the information is incorrect. The CMS reported more than 98.8% of submitted payment records were validated in 2014 using the automated algorithm, which rejects payment records if they report inconsistent physician identifiers and provides real-time feedback to industries.[13] The Physician Compare database developed by the CMS contains general information on all eligible healthcare providers (physicians, nurses and so on, with at least one practice location address/specialty code in the Medicare Provider Enrollment, Chain, and Ownership System who submitted at least one annual Medicare claim) including the National Provider Identification (NPI) number registry, sex, years in practice, specialty, medical school attended and practice location.[25]

We first linked physician information from the Open Payments database with the 2017 NPPES database using physicians' full name and the zip code for their primary practice location, an approach employed in previous studies.[10 15 19] Next, we used each physician's NPI number to linked the new merged dataset containing Open Payments and NPPES data with the Physician Compare database. Given that physicians who do not treat Medicare beneficiaries were not included in the Physician Compare database, our final sample size became 544 264 (see online supplementary figure 1 for more details).

Physician characteristics

We examined four characteristics of physicians: sex, years in practice, medical school attended and specialty. We defined years in practice as years since graduation from medical school and categorised physicians into four groups: ≤10, 11–20, 21–30 and >30 years since graduation. As in prior studies, we used the 2017 *U.S. News & World Report* research ranking,[26 27] to categorise medical schools into three groups: (1) top 20 US medical schools for research, (2) US medical schools ranked between 21 and 50 and (3) other medical schools (since only top 50 medical schools are ranked, we classified all unranked and foreign medical schools into this 'other' category). In table 1, we classified physician specialty into 33 distinct categories. We created indicator variables for practice location using the physical address of individual physicians in the NPPES database.

Payment data

Physician payments were classified into three categories: general payments, research payments and ownership interests. General payments included all forms of payments other than those classified for research purposes, including food and beverage, travel and lodging, speaker compensation, honoraria, consulting fees, gifts and education materials (eg, textbooks and reprints of journal articles). Research payments are financial payments related to research under a written contract or protocol (including payments for medical research writing or publication). Ownership interests include stocks or stock options (not publicly traded), partnership shares, bonds and ownership stake in a limited liability company.

Our primary outcome was the total annual value of reported payments—the sum of general payments, research payments and ownership interests—to physicians (calculated by dividing the total value of payments from

Table 1 Physician characteristics and type of industry payments

	Total physicians in the final database	Physicians who received general payments	Physicians who received research payments	Physicians who received ownership interests
Number of physicians	544 264	365 441	9456	2648
Sex, N (%)				
Female	173 715 (31.9)	106 308 (29.1)	1866 (19.7)	326 (12.3)
Male	370 549 (68.1)	259 133 (70.9)	7590 (80.3)	2322 (87.7)
Years in practice, mean (SD)	23 (12)	23 (12)	26 (10)	29 (10)
Medical school attended*, N (%)				
Top 20 schools in USA	60 711 (11.2)	39 250 (10.7)	1793 (19.0)	436 (16.5)
US schools ranked 21–50	95 294 (17.5)	62 349 (17.1)	1838 (19.4)	627 (23.7)
Other schools	388 259 (71.3)	263 842 (72.2)	5825 (61.6)	1585 (59.9)
Specialty, N (%)				
Primary care				
Internal Medicine	102 193 (18.8)	65 123 (17.8)	1217 (12.9)	152 (5.7)
Family Medicine	81 305 (14.9)	53 913 (14.8)	439 (4.6)	218 (8.2)
Paediatrics	6474 (1.2)	3613 (1.0)	91 (1.0)	8 (0.3)
Hospitalist	6888 (1.3)	3481 (1.0)	17 (0.2)	0 (0.0)
Surgery				
Orthopaedic	21 444 (3.9)	17 757 (4.9)	465 (4.9)	571 (21.6)
Neurosurgery	4568 (0.8)	3688 (1.0)	209 (2.2)	118 (4.5)
Thoracic/Vascular	2755 (0.5)	2296 (0.6)	100 (1.1)	14 (0.5)
Urology	8077 (1.5)	6794 (1.9)	192 (2.0)	663 (25.0)
Colorectal	945 (0.2)	760 (0.2)	33 (0.4)	3 (0.1)
General	25 543 (4.7)	19 446 (5.3)	467 (4.9)	64 (2.4)
Plastic	2634 (0.5)	2079 (0.6)	46 (0.5)	7 (0.3)
Otolaryngology	8148 (1.5)	6312 (1.7)	150 (1.6)	51 (1.9)
Obstetrics/Gynaecology	28 905 (5.3)	21 796 (6.0)	505 (5.3)	53 (2.0)
Specialists				
Endocrinology	4444 (0.8)	3406 (0.9)	216 (2.3)	7 (0.3)
Rheumatology	3555 (0.7)	2767 (0.8)	244 (2.6)	36 (1.4)
Haematology/Oncology	9369 (1.7)	7513 (2.1)	1040 (11.0)	185 (7.0)
Neurology	11 447 (2.1)	8365 (2.3)	564 (6.0)	14 (0.5)
Dermatology	10 303 (1.9)	7628 (2.1)	360 (3.8)	21 (0.8)
Cardiology	18 847 (3.5)	15 457 (4.2)	567 (6.0)	87 (3.3)
Allergy/Immunology	2887 (0.5)	2267 (0.6)	155 (1.6)	13 (0.5)
Ophthalmology	15 850 (2.9)	12 458 (3.4)	476 (5.0)	61 (2.3)
Gastroenterology	10 436 (1.9)	8479 (2.3)	361 (3.8)	21 (0.8)
Infectious Diseases	4654 (0.9)	3036 (0.8)	94 (1.0)	1 (0.0)
Pulmonology	5514 (1.0)	4192 (1.2)	122 (1.3)	3 (0.1)
Paediatric Specialty	3566 (0.7)	2172 (0.6)	138 (1.5)	2 (0.1)
Psychiatry	21 642 (4.0)	11 900 (3.3)	240 (2.5)	12 (0.5)
Radiology	24 816 (4.6)	12 094 (3.3)	241 (2.6)	79 (3.0)
Nephrology	6958 (1.3)	5406 (1.5)	141 (1.5)	9 (0.3)
Rehabilitation	7621 (1.4)	4558 (1.3)	34 (0.4)	13 (0.5)
Emergency Medicine	18 612 (3.4)	9619 (2.6)	122 (1.3)	14 (0.5)
Anaesthesiology	35 986 (6.6)	21 827 (6.0)	124 (1.3)	69 (2.6)
Others†	27 878 (5.1)	15 239 (4.2)	286 (3.0)	79 (3.0)

*Defined based on the *U.S. News & World Report* ranking (research ranking) in 2017.
†Others include surgical oncology, oral surgery, radio oncology, pathology, nuclear medicine and so on.

industry in 2015–2017 by three). Secondary outcomes were the annual value of each type of payment (ie, general payments, research payments and ownership interests) in 2015–2017. We focused on the total value of industry payments (we also examined the number of industry payments in a sensitivity analysis), because payments may be paid at once or split into multiple payments. We assumed that physicians who lacked payment information in the Open Payments database had not received payments from industry.

Statistical analyses

First, we analysed the concentration of total industry payments across physicians. We also ranked physicians by total value of payments received from industry and determined the proportion of total industry payments that were concentrated among physicians in the top 1% and 5% of all physicians by size of total industry payments from 2015 to 2017.

Second, we examined the association between physician characteristics and annual total industry payment value by constructing multivariable negative binomial regression models (to account for a right-skewed distribution of industry payments), adjusting for other physician characteristics and institution fixed effects. Physician characteristics evaluated in this model included sex, years in practice, medical school attended and clinical specialty. Institution fixed effects—indicator variables for each institution identified using each physician's primary practice address—were included to account for both measured and unmeasured characteristics of institutions that do not vary over time, effectively allowing us to compare physicians practicing in the same institution.[28–30] The unit of analysis was physicians and SEs were clustered at the institution level to account for potential correlations between physicians practicing in the same institution.[31] To calculate adjusted industry payment values for each group of physicians, after fitting regression models, we estimated predicted payment value for each physician, fixing physician characteristics at each level of the categories and averaged over our national sample (known as the marginal standardisation form of predictive margins, predictive margins, or margins of responses).[32]

Finally, we used a similar approach to that employed in our analysis of total industry payments to estimate associations between individual physician characteristics and the magnitude of each payment type separately (ie, general payments, research payments and ownership interests). For the analysis of general payments, as the industry marketing to physicians for drugs may have a different pattern than that for devices, we also conducted the analysis restricting to the payments made for drugs. For the analyses of research payments and ownership interests, given that the majority of physicians were receiving zero payment (98.3% and 99.5% of physicians were not receiving any research payments and ownership interests, respectively), we used two-part regression models[33] and evaluated physician characteristics associated with the odds of receiving any payments, as well as adjusted payment values for physicians who were receiving any payments (the first part was a logistic regression model estimating non-zero payments and the second part was a negative binomial regression model estimating the value of payments). For the analysis of ownership interests, we categorised physicians into four different specialties (primary care, surgery, specialists and others) to avoid unstable estimates due to smaller sample size.

Sensitivity analyses

We conducted sensitivity analyses for the analysis of total industry payments. First, to evaluate if our definitions of industry payments impacted our findings, we conducted multivariable logistic regression analyses using alternative definitions of industry payments: (1) whether physicians received any industry payments and (2) whether physicians received industry payments greater than $5000 (because the US Department of Health and Human Services specifically identifies payments exceeding this threshold as significant financial interests that require disclosure). Second, to test the impact of how we specify the distribution of payment data, we used alternative model specifications: (1) a two-part model[33] (the first part was a logistic regression model, estimating non-zero payments and the second part was a negative binomial regression model, estimating the value of payments) and (2) ordinary least square regression with Huber-White heteroscedasticity-robust SEs. Last, to evaluate the generalisability of our primary analysis to physicians who do not treat Medicare beneficiaries (and therefore, not included in the Physician Compare database), we examined the association between physician characteristics included in the Open Payments-NPPES linked database (physician sex and specialty) and the value of industry payments, without restricting physicians included in the Physician Compare database. All analyses were conducted using Stata, V.15 (Stata).

Patient and public involvement

No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for design or implementation of the study. No patients were asked to advise on interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants or the relevant patient community.

RESULTS

Of 544 264 physicians who were treating Medicare beneficiaries, a total of $5.8 billion in industry payments were made to 365 801 physicians in 2015–2017, with a median (IQR) annual payment value of $199 ($42–$878). About 68% (370 549/544 264) of physicians were male and mean (SD) years in practice was 23 (12) years (table 1). Industry payments were concentrated among a small number of physicians who accounted for a large share

of the total amount of payments (online supplementary figure 2). The top 1% and 5% of physicians accounted for 73% and 91% of total industry payments, respectively.

Association between physician characteristics and the value of total industry payments

After adjusting for other physician characteristics and institution fixed effects, male physicians received significantly larger value of industry payments than female physicians (adjusted annual payment value, $4164 for male vs $1650 for female; adjusted % difference, +152%; 95% CI +85% to +244%; p<0.001) meaning that the average male physicians had payments totalling 2.5 times that of female physicians (table 2). Physicians with 21–30 years in practice, received the largest payments, $5231 (adjusted annual payment value), followed by $3878, for >30 years, $3180, for 11–20 years and $906, for those with ≤10 years in practice. Physicians who attended US medical schools ranked below 50 or foreign medical schools, received lower payments compared with physicians who attended top 20 research medical schools.

After adjusting for other physician characteristics, orthopaedic surgeons received the highest payments (adjusted payment value, $18 650; 95% CI $14 475 to $22 826), followed by neurosurgeons ($15 937; 95% CI $7861 to $24 012) and endocrinologists ($11 829; 95% CI $9350 to $14 309) (table 2). Hospitalists received the lowest payments ($312; 95% CI $212 to $412), followed by paediatricians ($1050; 95% CI $742 to $1359) and anaesthesiologists ($1106; 95% CI $836 to $1375).

General payments

A total of 365 441 physicians treating Medicare beneficiaries, received general payments in 2015–2017, with a median (IQR) annual payment value of $195 ($42–$852). Our results for general payments were similar to total payments (suggesting that our findings for total payments were driven largely by general payments). We found that general payments were higher for male physicians, physicians with 21–30 years in practice and physicians who attended top 20 research medical schools (table 3A). Physicians in orthopaedic, neurosurgery and endocrinology received the highest payments, while hospitalists, emergency physicians and anaesthesiologists received the lowest general payments. When we restricted our analysis to payments for drugs and not for devices, we also observed the highest amount of industry payments were made to endocrinologists, but not to physicians in orthopaedic and neurosurgery (online supplementary table 1).

Research payments

A total of 9456 physicians treating Medicare beneficiaries received research payments in 2015–2017, with a median (IQR) annual payment value of $827 ($233 to $3667). We found that male physicians, physicians practicing for more than 10 years and physicians who attended top 20 medical schools, were associated with the receiving research payments (table 3B). Haematologists/oncologists, allergists/immunologists, rheumatologists and endocrinologists were the most likely to receive research payments, while hospitalists, anaesthesiology and physicians in rehabilitation, were the least likely. Among physicians receiving any research payments, allergists/immunologists received the largest research payments.

Ownership interests

A total of 2648 physicians treating Medicare beneficiaries received ownership interests in 2015–2017, with a median (IQR) annual value of $17 002 ($1324–$73 567). We found that male physicians, physicians practicing for more than 10 years, and physicians who attended top 50 medical schools, were associated with the receiving ownership interests (table 3C). Across specialties, surgeons were receiving higher ownership interests than other types of physicians, including specialists and primary care physicians.

Sensitivity analyses

Our findings were not qualitatively affected using alternative definitions of industry payments (online supplementary tables 2 and 3), and alternative specification of the distribution of payment data (online supplementary tables 4 and 5). Physicians and specialties were similar to physicians who were included in the Physician Compare database and those who were not (online supplementary tables 6) and our findings were similar when we analysed the data without restricting our study cohort to physicians included in the Physician Compare database (online supplementary tables 7).

DISCUSSION

Using payment data from industry to physicians in 2015–2017 in the CMS Open Payments database linked with comprehensive data on practicing physicians in the U.S., we found that industry payments were concentrated among a small number of physicians; the top 5% of physicians by total payment value accounted for 91% of total industry payments to physicians in 2015–2017. We also found that, within the same institution, male sex, physicians who have more years in practice and those who graduated from medical schools with highly-ranked research programmes, were associated with higher total value of industry payments. Across specialties, orthopaedic surgeons, neurosurgeons and endocrinologists received the highest total industry payments. Taken together, these findings extend our understanding of the financial relationships between industry and US practicing physicians and how industry payments to physicians may influence prescribing practices.

These findings have important policy implications. Although the total number of industry payments to physicians has declined recently,[18 34] the total dollar value of payments remains as high as $8.4 billion,[34] indicating that improved transparency through the *Physician Payments Sunshine Act* alone may not be adequate to change how industry interact with physicians. Our findings suggest

Table 2 Comparison of industry total payment value according to physician characteristics

	Mean value of payments			
	Unadjusted	Adjusted (95% CI)	Adjusted % difference (95% CI)	P value
Sex				
Female	$1090	$1650 (1149 to 2151)	Ref	–
Male	$4735	$4164 (3304 to 5025)	+152% (+85% to+244%)	<0.001
Years in practice				
≤10	$632	$906 (663 to 1148)	Ref	–
11–20	$2712	$3180 (2420 to 3941)	+251% (+135% to+424%)	<0.001
21–30	$5160	$5231 (3495 to 6966)	+478% (+304% to+726%)	<0.001
>30	$4930	$3878 (3342 to 4414)	+328% (+228% to+460%)	<0.001
Medical school attended*				
Top 20 school in USA	$5249	$3759 (3265 to 4254)	Ref	–
US schools ranked 21–50	$5527	$5477 (2604 to 8350)	+46% (-8% to +131%)	0.11
Other schools	$2830	$3003 (2687 to 3320)	–20% (-31% to -7%)	0.004
Specialty				
Primary care				
Internal Medicine	$1747	$2641 (1260 to 4022)	Ref	–
Family Medicine	$2590	$1515 (323 to 2706)	–43% (–73% to +23%)	0.15
Paediatrics	$669	$1050 (742 to 1359)	–60% (-78% to -27%)	0.003
Hospitalist	$208	$312 (212 to 412)	–88% (-94% to -78%)	<0.001
Surgery				
Orthopaedic	$23 897	$18 650 (14 475 to 22826)	+606% (+327% to+1067%)	<0.001
Neurosurgery	$20 156	$15 937 (7861 to 24012)	+503% (+204% to+1098%)	<0.001
Thoracic/Vascular	$5804	$4580 (3473 to 5686)	+73% (+3% to+192%)	0.04
Urology	$4849	$4381 (3461 to 5300)	+66% (-3% to +182%)	0.06
Colorectal	$3417	$3252 (2300 to 4204)	+23% (-32% to +122%)	0.49
General	$2791	$2983 (2294 to 3672)	+13% (-35% to +95%)	0.66
Plastic	$2650	$2467 (1894 to 3040)	–7% (–47% to +64%)	0.81
Otolaryngology	$1400	$1333 (1062 to 1604)	–50% (-70% to -14%)	0.01
Obstetrics/Gynaecology	$932	$1249 (921 to 1578)	–53% (-74% to -15%)	0.01
Specialists				
Endocrinology	$11 327	$11 829 (9350 to 14309)	+348% (+152% to+695%)	<0.001
Rheumatology	$7252	$8049 (5982 to 10117)	+205% (+73% to+436%)	<0.001
Haematology/Oncology	$7578	$7676 (6288 to 9063)	+191% (+68% to+402%)	<0.001
Neurology	$6244	$7592 (5938 to 9247)	+188% (+65% to+402%)	<0.001
Dermatology	$4239	$5238 (4169 to 6307)	+98% (+12% to+251%)	0.02
Cardiology	$6024	$4932 (4219 to 5646)	+87% (+15% to+204%)	0.01
Allergy/Immunology	$4625	$4729 (3582 to 5876)	+79% (+3% to+211%)	0.04
Ophthalmology	$4659	$4487 (2406 to 6568)	+70% (-13% to +232%)	0.12
Gastroenterology	$4214	$3730 (3026 to 4434)	+41% (-16% to +138%)	0.20
Infectious Diseases	$2713	$2658 (2034 to 3281)	+1% (-44% to +80%)	0.98
Pulmonology	$2889	$2462 (2020 to 2904)	–7% (–45% to +57%)	0.79
Paediatric Specialty	$1877	$1970 (1412 to 2528)	–25% (–59% to +35%)	0.33
Psychiatry	$1722	$1852 (1229 to 2476)	–30% (–62% to +29%)	0.25
Radiology	$2141	$1854 (1340 to 2368)	–30% (–60% to +22%)	0.21
Nephrology	$1825	$1694 (1188 to 2199)	–36% (–64% to +13%)	0.12

Continued

Table 2 Continued

	Mean value of payments			
	Unadjusted	Adjusted (95% CI)	Adjusted % difference (95% CI)	P value
Rehabilitation	$1188	$1471 (1122 to 1820)	−44% (-68% to -4%)	0.03
Emergency Medicine	$1400	$1341 (379 to 2303)	−49% (−78% to +18%)	0.11
Anaesthesiology	$1088	$1106 (836 to 1375)	−58% (-75% to -29%)	<0.001
Others†	$1790	$1638 (1200 to 2075)	−38% (−65% to +10%)	0.10

*Defined based on the *U.S. News & World Report* ranking (research ranking) in 2017.
†Others include surgical oncology, oral surgery, radio oncology, pathology, nuclear medicine and so on.

that industry may be targeting certain types of physicians—who are likely to be key thought leaders, content experts and clinical experts—who themselves may be prescribing a large amount of medications, or who may be influential in changing prescription practices of other physicians. Therefore, our findings should be informative for policymakers to design policies that can effectively minimise the influence of industry on medical practice. Further longitudinal studies are warranted to investigate the causal effect of industry marketing on physician prescriptions and patient outcome.

Extensive research has shown that even small financial or in-kind gifts or compensation from industry may affect physicians' decision-making.[1 5 35] Yet, less is known about physician characteristics associated with receipt of larger industry payments. Prior studies included physician sex,[14–16] years in practice,[16 18] and clinical specialty[10 15 16] as physician-level covariates. Therefore, if there is a difference in sex distribution according to medical school research ranking, for example, then failing to adjust for medical school attended could lead to biased results. Our findings indicate that, even after adjustment for years in practice, medical school attended and specialty, male sex was still associated with larger payments from industry. This finding may be explained by the fact that female physicians may have different preferences for industry engagement[36]or that they may be less likely to negotiate for higher payments when they do engage with industry.[14]

Our findings indicate that physicians with more years in practice received higher payments from industry, compared with less experienced physicians, which is consistent with the recent findings using the 2014–2016 Open Payments data.[18] These findings may reflect the fact that industry is most interested in building relationships with physicians who are experts in their field given that such expertise and experience can be obtained over many years of work in research and/or clinical practice.[37] Our finding that physicians who attended elite research medical schools on average, received higher industry payments than physicians who attended less prestigious research medical schools is also a new finding and may reflect these same tendencies.

We found that orthopaedic surgeons, neurosurgeons and endocrinologists received higher industry payments (both total and general payments) than physicians from other specialties, even after adjusting for other physician characteristics, including age and clinical experience. Meanwhile, we found that orthopaedic surgeons and neurosurgeons received fewer general payments from the industry when we restricted to general payments for drugs (ie, excluding general payments for devices). These results indicate that high industry payments to orthopaedic surgeons and neurosurgeons likely reflect payments from the medical device industry, a finding that has been previously demonstrated.[38–40] Endocrinologists may receive higher payments from industry because they are centrally involved in treating several highly prevalent and expensive chronic diseases, including diabetes, hyperlipidaemia and obesity. Drug and medical device companies generate large amounts of revenue from treatments targeting these diseases. In 2017, for example, there were 25 (non-insulin) glucose-lowering agents among 11 classes of therapies, creating a highly-competitive market for medications used by endocrinologists.[41] This hypothesis is supported by a recent study of industry payments to journal editors, which suggested that editors of endocrinology journals receive higher industry payments than editors of journals focused on other medical specialties.[42]

Our study has limitations. First, although the quality of Open Payments data has improved over time,[13] it is still possible that the database has inaccuracies about the value of payments actually received by physicians. The Open Payments Data, however, are the most comprehensive and reliable data of industry payments to physicians available and the CMS encourages all physicians to review and dispute incorrect information prior to publication and nearly 30% of the total value of 2014 payments were actually reviewed.[13] Second, our sample did not include physicians who had no Medicare claims, and, therefore, these findings may not be generalisable to physicians not caring for Medicare beneficiaries. However, our findings were not qualitatively affected by inclusion of all physicians regardless of whether they were treating Medicare beneficiaries in sensitivity analyses. Third, although we included an extensive set of physician characteristics in our regression models, we could not rule out the possibility of residual confounding, due to unmeasured physician characteristics, not included in our analyses. Last, it is possible that pharmaceutical and medical device companies underreport the value of payments to physicians.

Table 3A Comparison of industry general payment value according to physician characteristics

	Mean value of payments		Adjusted % difference (95% CI)	P value
	Unadjusted	Adjusted (95% CI)		
Sex				
Female	$804	$1142 (997 to 1287)	Ref	–
Male	$3053	$2627 (2488 to 2766)	+130% (+104% to+159%)	<0.001
Years in practice				
≤10	$495	$744 (669 to 818)	Ref	–
11–20	$2061	$2207 (2054 to 2359)	+197% (+176% to +219%)	<0.001
21–30	$2856	$2895 (2531 to 3259)	+289% (+222% to +371%)	<0.001
>30	$3344	$2540 (2309 to 2770)	+241% (+206% to +281%)	<0.001
Medical school attended*				
Top-20 school in USA	$4024	$3014 (2720 to 3307)	Ref	–
US schools ranked 21–50	$2570	$2250 (2047 to 2452)	–25% (–34% to –15%)	<0.001
Other schools	$2014	$2132 (1989 to 2275)	–29% (–36% to –22%)	<0.001
Specialty				
Primary care				
Internal Medicine	$1188	$1268 (1193 to 1342)	Ref	–
Family Medicine	$506	$633 (478 to 788)	–50% (–61% to –36%)	<0.001
Paediatrics	$619	$817 (665 to 970)	–36% (–47% to –22%)	<0.001
Hospitalist	$183	$232 (178 to 287)	–82% (–86% to –77%)	<0.001
Surgery				
Orthopaedic	$14 502	$10 948 (8917 to 12979)	+764% (+612% to +948%)	<0.001
Neurosurgery	$13 807	$10 634 (4363 to 16905)	+739% (+365% to +1414%)	<0.001
Thoracic/Vascular	$5228	$3912 (3181 to 4643)	+209% (+154% to +275%)	<0.001
Urology	$2802	$2427 (2107 to 2748)	+91% (+66% to +120%)	<0.001
Colorectal	$3211	$2828 (2086 to 3570)	+123% (+71% to +191%)	<0.001
General	$2173	$2242 (1830 to 2654)	+77% (+46% to +114%)	<0.001
Plastic	$2171	$1958 (1547 to 2369)	+54% (+25% to +91%)	<0.001
Otolaryngology	$955	$875 (773 to 978)	–31% (–39% to –22%)	<0.001
Obstetrics/Gynaecology	$815	$926 (776 to 1075)	–27% (–38% to –14%)	<0.001
Specialists				
Endocrinology	$10 908	$10 560 (9324 to 11796)	+733% (+633% to +847%)	<0.001
Rheumatology	$6080	$6283 (5156 to 7411)	+396% (+311% to +498%)	<0.001
Haematology/Oncology	$6166	$5695 (5120 to 6270)	+349% (+303% to +401%)	<0.001
Neurology	$5871	$6296 (5604 to 6987)	+397% (+339% to +461%)	<0.001
Dermatology	$3435	$3902 (3463 to 4341)	+208% (+172% to +249%)	<0.001
Cardiology	$5146	$4021 (3751 to 4290)	+217% (+192% to +245%)	<0.001
Allergy/Immunology	$3331	$3280 (2729 to 3831)	+159% (+117% to +209%)	<0.001
Ophthalmology	$2629	$2263 (1849 to 2678)	+79% (+48% to +116%)	<0.001
Gastroenterology	$3487	$2978 (2658 to 3297)	+135% (+109% to +164%)	<0.001
Infectious Diseases	$2558	$2350 (1935 to 2766)	+85% (+54% to +123%)	<0.001
Pulmonology	$2689	$2211 (1887 to 2534)	+74% (+49% to +104%)	<0.001
Paediatric Specialty	$1749	$1650 (1324 to 1976)	+30% (+6% to +60%)	0.01
Psychiatry	$1417	$1284 (1133 to 1436)	+1% (–11% to +16%)	0.85
Radiology	$1229	$1118 (862 to 1375)	–12% (–30% to +11%)	0.29
Nephrology	$1380	$1231 (957 to 1505)	–3% (–23% to +22%)	0.80

Continued

Table 3A Continued

	Mean value of payments		Adjusted % difference (95% CI)	P value
	Unadjusted	Adjusted (95% CI)		
Rehabilitation	$1059	$1166 (975 to 1358)	–8% (–22% to +9%)	0.34
Emergency Medicine	$668	$592 (512 to 672)	–53% (–59% to –46%)	<0.001
Anaesthesiology	$669	$671 (573 to 769)	–47% (–55% to –38%)	<0.001
Others†	$1190	$1122 (856 to 1388)	–12% (–30% to +12%)	0.31

*Defined based on the *U.S. News & World Report* ranking (research ranking) in 2017.
†Others include surgical oncology, oral surgery, radio oncology, pathology, nuclear medicine and so on.

Table 3B OR of receiving research payments and comparison of the received payment value according to physician characteristics

	No (%)	Median (IQR) annual payment value for physicians receiving payments	Adjusted OR (95% CI)	P value
Sex				
Female	1866 (1.1)	$501 (127 to 2409)	Ref	–
Male	7590 (2.1)	$928 (167 to 4000)	1.73 (1.64 to 1.83)	<0.001
Years in practice				
≤10	423 (0.4)	$376 (100 to 1186)	Ref	–
11–20	2724 (1.7)	$651 (200 to 2890)	3.51 (3.16 to 3.89)	<0.001
21–30	3017 (2.2)	$868 (250 to 3980)	4.16 (3.74 to 4.62)	<0.001
>30	3292 (2.2)	$1110 (283 to 4425)	3.46 (3.11 to 3.85)	<0.001
Medical school attended*				
Top-20 school in USA	1793 (3.0)	$1005 (299 to 4237)	Ref	–
US schools ranked 21–50	1838 (1.9)	$892 (217 to 3686)	0.73 (0.68 to 0.78)	<0.001
Other schools	5825 (1.5)	$751 (219 to 3438)	0.61 (0.57 to 0.64)	<0.001
Specialty				
Primary care				
Internal Medicine	1217 (1.2)	$760 (197 to 3333)	Ref	–
Family Medicine	439 (0.5)	$646 (94 to 2823)	0.46 (0.40 to 0.52)	<0.001
Paediatrics	91 (1.4)	$602 (271 to 1994)	1.29 (1.02 to 1.63)	0.35
Hospitalist	17 (0.3)	$1245 (400 to 2674)	0.24 (0.15 to 0.38)	<0.001
Surgery				
Orthopaedic	465 (2.2)	$2240 (536 to 6650)	1.42 (1.25 to 1.62)	0.65
Neurosurgery	209 (4.6)	$1400 (333 to 4933)	3.01 (2.52 to 3.59)	<0.001
Thoracic/Vascular	100 (3.6)	$350 (137 to 1096)	2.19 (1.77 to 2.72)	<0.001
Urology	192 (2.4)	$717 (238 to 2703)	1.56 (1.32 to 1.86)	<0.001
Colorectal	33 (3.5)	$466 (158 to 1900)	2.36 (1.58 to 3.52)	<0.001
General	467 (1.8)	$437 (200 to 1330)	1.31 (1.15 to 1.49)	<0.001
Plastic	46 (1.8)	$1197 (197 to 4483)	1.12 (0.83 to 1.52)	0.47
Otolaryngology	150 (1.8)	$446 (197 to 3771)	1.25 (1.03 to 1.52)	0.03
Obstetrics/Gynaecology	505 (1.8)	$331 (17 to 1839)	1.54 (1.36 to 1.74)	<0.001
Specialists				
Endocrinology	216 (4.9)	$948 (147 to 5094)	4.02 (3.45 to 4.69)	<0.001
Rheumatology	244 (6.9)	$688 (171 to 3615)	5.62 (4.77 to 6.62)	<0.001
Haematology/Oncology	1040 (11.1)	$804 (183 to 2673)	8.90 (8.00 to 9.90)	<0.001
Neurology	564 (4.9)	$653 (215 to 3608)	3.93 (3.47 to 4.44)	<0.001
Dermatology	360 (3.5)	$2208 (363 to 10 648)	2.89 (2.52 to 3.31)	<0.001
Cardiology	567 (3.0)	$754 (183 to 3159)	1.95 (1.73 to 2.20)	<0.001
Allergy/Immunology	155 (5.4)	$3356 (550 to 21 467)	4.12 (3.39 to 5.00)	<0.001

Continued

Table 3B Continued

	No (%)	Median (IQR) annual payment value for physicians receiving payments	Adjusted OR (95% CI)	P value
Ophthalmology	476 (3.0)	$1311 (418 to 5745)	2.09 (1.83 to 2.38)	<0.001
Gastroenterology	361 (3.5)	$1667 (386 to 4330)	2.33 (2.01 to 2.69)	<0.001
Infectious Diseases	94 (2.0)	$1102 (290 to 3770)	1.50 (1.21 to 1.85)	<0.001
Pulmonology	122 (2.2)	$795 (280 to 3902)	1.51 (1.23 to 1.85)	<0.001
Paediatric Specialty	138 (3.9)	$479 (180 to 1130)	3.00 (2.49 to 3.61)	<0.001
Psychiatry	240 (1.1)	$1344 (459 to 7083)	0.87 (0.74 to 1.01)	0.07
Radiology	241 (1.0)	$2206 (525 to 7206)	0.68 (0.57 to 0.82)	<0.001
Nephrology	141 (2.0)	$604 (263 to 3550)	1.46 (1.21 to 1.76)	<0.001
Rehabilitation	34 (0.5)	$909 (188 to 3812)	0.37 (0.26 to 0.53)	<0.001
Emergency Medicine	122 (0.7)	$567 (228 to 2000)	0.50 (0.41 to 0.61)	<0.001
Anaesthesiology	124 (0.3)	$1343 (399 to 4042)	0.25 (0.21 to 0.31)	<0.001
Others†	286 (1.0)	$728 (233 to 2493)	0.76 (0.66 to 0.87)	<0.001

*Defined based on the *U.S. News & World Report* ranking (research ranking) in 2017.
†Others include surgical oncology, oral surgery, radio oncology, pathology, nuclear medicine and so on.

Table 3C OR of receiving ownership interests and comparison of the received payment value according to physician characteristics

Value invested	No (%)	Median (IQR) annual payment value for physicians receiving payments	Adjusted OR (95% CI)	P value
Sex				
Female	305 (0.2)	$33 (7 to 200)	Ref	Ref
Male	1995 (0.5)	$6000 (192 to 75 595)	2.20 (1.92 to 2.51)	<0.001
Years in practice				
≤10	48 (0.1)	$3991 (6 to 22 954)	Ref	Ref
11–20	525 (0.3)	$6667 (193 to 25 000)	6.30 (4.67 to 8.49)	<0.001
21–30	806 (0.6)	$4686 (280 to 35 217)	9.99 (7.48 to 13.35)	<0.001
>30	921 (0.6)	$4686 (289 to 39 250)	9.68 (7.24 to 12.95)	<0.001
Medical school attended*				
Top 20 school in USA	365 (0.6)	$10 000 (755 to 33 339)	Ref	Ref
US schools ranked 21–50	545 (0.6)	$6202 (370 to 33 667)	1.00 (0.87 to 1.15)	0.96
Other schools	1390 (0.4)	$4500 (192 to 32 109)	0.75 (0.66 to 0.85)	<0.001
Specialty				
Primary care	367 (0.2)	$20 (7 to 57)	Ref	Ref
Surgery	1275 (1.2)	$8333 (425 to 38 155)	5.44 (4.58 to 6.46)	<0.001
Specialists	584 (0.3)	$14 495 (1667 to 52 500)	1.18 (0.98 to 1.43)	0.09
Others†	74 (0.3)	$17 027 (3333 to 53 972)	1.18 (0.87 to 1.61)	0.29
Value of interest	**No (%)**	**Median (IQR) annual payment value for physicians receiving payments**	**Adjusted OR (95% CI)**	**P value**
Sex				
Female	318 (0.2)	$89 (11 to 11 591)	Ref	Ref
Male	2154 (0.6)	$13 890 (1944 to 52 247)	2.31 (2.03 to 2.63)	<0.001
Years in practice				
≤10	51 (0.1)	$5649 (11 to 30 604)	Ref	Ref

Continued

Table 3C Continued

Value invested	No (%)	Median (IQR) annual payment value for physicians receiving payments	Adjusted OR (95% CI)	P value
11–20	582 (0.4)	$10 625 (755 to 30 882)	6.53 (4.90 to 8.71)	<0.001
21–30	901 (0.7)	$11 067 (1100 to 46 933)	10.39 (7.86 to 13.74)	<0.001
>30	938 (0.6)	$12 062 (1820 to 57 265)	9.13 (6.89 to 12.09)	<0.001
Medical school attended*				
Top 20 school in USA	420 (0.7)	$11 052 (1995 to 41805)	Ref	Ref
US schools ranked 21–50	588 (0.6)	$12 250 (1667 to 50 143)	0.94 (0.83 to 1.07)	0.35
Other schools	1464 (0.4)	$10 360 (660 to 42 659)	0.69 (0.61 to 0.78)	<0.001
Specialty				
Primary care	377 (0.2)	$69 (11 to 129)	Ref	Ref
Surgery	1382 (1.3)	$19 766 (3183 to 55 715)	5.69 (4.80 to 6.74)	<0.001
Specialists	637 (0.3)	$12 178 (2500 to 67 629)	1.25 (1.04 to 1.50)	0.02
Others†	76 (0.3)	$17 707 (2504 to 70 084)	1.18 (0.87 to 1.59)	0.28

*Defined based on the *U.S. News & World Report* ranking (research ranking) in 2017.
†Others include surgical oncology, oral surgery, radio oncology, pathology, nuclear medicine and so on.

CONCLUSION

Using a contemporary national database of industry payments to physicians in 2015–2017, linked to a comprehensive database of practicing US physicians, we found that male physicians, more experienced physicians and physicians from medical schools with highly-ranked research programmes were more likely to receive higher payments from industry than other physicians. In addition, orthopaedic surgeons, neurosurgeons and endocrinologists received larger overall payments from industry than did other types of clinicians. These findings highlight that promotional activities of the industry target clinician-scientists in specific specialties with sufficient clinical experience to influence prescribing practices.

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