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Trends in financial relationships between industry and radiation oncologists versus other physicians in the United States from 2014 to 2018

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Abstract

Purpose: The Open Payments (OP) transparency program publishes data on industry-physician payments, in part to discourage relationships considered inappropriate including gifts, meals, and speaker's bureau fees. We evaluated trends in physician-level payments to test whether implementation of OP resulted in fewer industry-radiation oncologist (RO) interactions or shifted interactions towards those considered more appropriate as compared to medical oncologists (MOs) and other hospital-based physicians (HBPs).

Methods and Materials: We performed a retrospective, population-based cohort study of practicing US ROs versus MOs and HBPs in 2014 matched to general (non-research) payments between 2014–2018. Trends in payments were analyzed and reported by nature of payment. Values of payments to ROs from the top 10 companies were identified.

Results: From 2014–2018, 3,379 (90.3%) ROs accepted 106,930 payments totaling \$40.8 million. The per-physician number and value of payments was lower in RO than MO, and higher than HBPs. The proportion of ROs accepting payments increased from 61.8% in 2014 to 64.2% in 2018; the proportion of MOs accepting payments decreased from 78.7% to 77.7%; the proportion of HBPs decreased from 40.8% to 37.5%, respectively. The annual per-physician value and number of payments accepted by RO and MO increased. Payments in entertainment, meals, travel/lodging and gifts increased among ROs and remained stable or decreased among MOs and HBPs.

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Consulting payments increased across all groups. Top RO payors produced novel cancer therapeutics, hydrogel spacers, radiation treatment machines, and opioids.

Conclusions: Industry payments to ROs have become more common since OP's inception, while becoming less common for MOs and HBPs. Payments to ROs and MOs have become more frequent and of modestly increasing value, compared to other HBPs for whom the value is decreasing. No large changes in the nature of relationships were seen in ROs. Increased engagement with financial conflicts of interest is needed in RO.

Introduction

Collaborations between pharmaceutical, device, and biotechnology companies and physicians help drive innovations in oncologic practice¹. However, industry involvement in various aspects of oncology has grown both increasingly common and complex over time, with concomitant increasing government media, professional, and public scrutiny^{1,2}. As oncology has become a lucrative business drawing significant investments^{3,4}, there has been an evolving movement to ensure that financial incentives remain aligned with patient-centered goals⁵. Financial relationships between industry and physicians introduce conflicts of interest, creating the potential for undue influence in decision-making⁵⁻⁷. These have unique ethical concerns for oncologists.⁸ Evidence has shown that industry-physician interactions can introduce commercial bias into medical research, guideline development and patient care in the form of prescribing and intervention^{5,7,9}. The breadth of these interactions thus holds broad implications for the United States healthcare system, especially in the sphere of oncology, as increased healthcare costs and greater attention to spending in this field contribute to a growing interest in alternative models of value-based care.

These concerns contributed to the development of the Open Payments program (Open Payments), established by the Affordable Care Act and managed by the Centers for Medicare and Medicaid Services (CMS)^{10,11}. The Open Payments (OP) program collects and makes public data on industry payments to physicians, to promote transparency and “to help prevent inappropriate influence on research, education and decision-making”.^{12,13} Open Payments does not determine whether or not financial relationships are problematic; rather, it instead provides transparency by mandating the disclosure of all industry payments to physicians and making these payments publicly available on a searchable website¹⁰. Guidance regarding whether financial relationships are considered inappropriate or problematic, such as payments for gifts, meals, and speaker's bureau fees⁵, has been established by the National Academy of Medicine, which can facilitate interpretation of Open Payments data by professional organizations, government agencies, physicians, patients, and industry.

Since CMS began publishing industry payments to physicians 2014 the gross magnitude of these interactions has been revealed, with a total value of over \$40 billion¹⁴. However, the scope of radiation oncologists' (ROs) ties to industry and the impact of Open Payments on these relationships is not well understood. Therefore, our aim was to evaluate trends in physician-level payments to test whether the implementation of Open Payments has decreased ROs' interactions with industry or shifted them towards those considered more

appropriate. We also compared trends in radiation oncology to those in other similar specialties, including medical oncology (MO) and other hospital-based physicians (HBPs).

Methods and Materials

Study Cohort

We performed a retrospective cohort study of US physicians practicing in 2014 as per the National Plan and Provider Enumeration System (NPPES)¹⁵ (see eFigure1 for physician selection). This cohort of physicians was followed over time to determine trends in the extent and nature of their interactions with industry since the inception of Open Payments. Physicians who either activated or deactivated their NPPES record during the study period of 2014–2018 were excluded from the cohort to account for physicians starting practice or retiring during the period. In addition, physicians outside US states and hospital referral regions were excluded.

We matched the 2015 and 2018 Open Payments physician supplemental files to the NPPES database, based on text-string identifier (>95% fidelity), in order to link physician NPI to Open Payments records. NPPES includes all physicians who are covered recipients in the Open Payments program with a National Provider Identifier (NPI) and is used to verify Open Payments records; therefore, we used NPPES specialty counts to determine the number of physicians eligible for inclusion in the Open Payments database.

In order to calculate specialty-specific payment estimates, we limited our analyses to doctors in allopathic and osteopathic primary specialties within the NPPES provider taxonomy (excluding other professions such as podiatrists and chiropractors). Data were aggregated per the provider taxonomy classification¹⁶.

Physician characteristics

In order to assess the possible impact of Open Payments, we selected ‘practicing physicians’ based on Medicare participation and inclusion in the Physician Compare database. Physician payment data were linked to demographic data in NPPES, including physician gender (male/female) and specialty category, grouped by specialty (RO versus MO and other HBPs), in order to compare ROs to national trends for similar physicians enrolled in Medicare and thus potentially included in Open Payments. MOs included physicians with a primary specialty of hematology/oncology, medical oncology, or pediatric hematology-oncology per the provider taxonomy classification¹⁶. ‘Hospital-based’ specialties were grouped by Medicare Data on Provider Practice and Specialty taxonomy classifications¹⁷. The hospital-based specialty classification represents specialties that typically provide services in a hospital-owned facility (inpatient, outpatient, or emergency) setting, use hospital facilities and equipment, have complex technical equipment, and require specially trained staff and extensive technologic support, and includes Radiation Oncology, Anesthesiology, Radiology, Emergency Medicine, Pathology, and Nuclear Medicine. Additionally, physician data were linked via NPI to Physician Compare demographic data, which included years in practice (grouped by <10, 10–19, 20–29, and 30+ years, calculated from graduation year) and hospital affiliations (see below).

Practice characteristics

To account for regional variation in practice setting and spending⁵, we linked NPPES physician practice zip codes to the Dartmouth Atlas Hospital Referral Region (HRR) and corresponding 2017 total price-, age-, sex-, and race-adjusted Medicare spending per beneficiary¹⁸. We categorized practice HRR into three spending groups by dividing per-beneficiary spending into quintiles then sub-grouping into tertiles (low, average, and high) with the lowest quintile (< 20th percentile) and highest quintile (>80th percentile) as the distinct low and high categories, respectively, similar to other studies¹⁹.

To account for practice-level factors⁵, we linked Physician Compare hospital affiliation data to the NCI SEER-Medicare Hospital File to determine medical school affiliation and NCI designation (both clinical and comprehensive). The 2014 NCI hospital file includes data from Healthcare Cost Report (HCRIS) and the Provider of Service (POS) survey obtained from CMS, if linked to any reported hospital affiliation in Physician Compare for each physician. Practice setting was defined as hospital-based (including those affiliated with a medical school with or without NCI designation, or unaffiliated/unknown) or no hospital affiliation.

Payment Data

To determine trends in physician-industry interactions since the inception of Open Payments, we analyzed Open Payments data on industry payments to physicians made between January 1, 2014 and December 31, 2018. While Open Payments data began in 2013, the 2013 data included only partial-year reporting²⁰ so we excluded it from our analysis. All dollar amounts were adjusted for inflation to the 2014 Consumer Price Index²¹. We included general payments, defined as “payments or other transfers of value made that are not in connection with a research protocol”²². We excluded research payments and ownership interests in order to best understand changes at the level of the individual physician, and excluded records of payments to teaching hospitals (as opposed to individual physicians).

General payments were also analyzed by nature of payment. Nature of payment categories were combined into the following major groups: non-accredited education; consulting; accredited education; investment interest, royalty or licensing fees; charity; and, entertainment, meals, travel/lodging, and gifts (see eTable 1 for nature-of-payments category taxonomy).

Analyses

First, the annual and cumulative proportion of physicians receiving one or more payment(s), total value of payments, total number of payments, and the median and mean per-physician value of payments were calculated. Next, trends in the annual rate of physicians receiving one or more payment(s), median annual number of payments, and median annual value of payments were estimated. We also calculated the proportion of physicians in each group receiving a cumulative total value greater than \$10,000. We then evaluated the distribution of the annual number and value of payments by nature of payment category and assessed trends over time for value and number of payments by nature of payment category.

Trends over time were tested using logistic, Poisson and linear generalized estimating equations²³ controlling for physician-level repeated measures, for proportion of physicians receiving payments, number of payments, and value of payments, respectively as the dependent variables with year as the independent variable. Value-of-payment data were highly skewed, so a gamma distribution with log-transformation¹⁶ was used for the analyses of total annual values. Trend analyses were stratified by physician group (radiation oncologists and other physicians) and by nature of payment. We then assessed whether annual trends in payments persisted after adjusting for physician and practice variables that may influence receipt of payments¹, including gender, years in practice, HRR spending tertile, and practice setting for ROs and MOs. We included MOs as a relevant oncology practice comparison group for which the NCI designation may influence payments.

Data from the top 10 companies with general payments to practicing ROs were summarized. Generic terms were determined for related products associated with those payments as indicated in Open Payments data.

Finally, given there was a single large outlier for value of payments in RO in 2018 and similar large outliers in other physician groups, trends analyses were repeated after winsorizing the top 0.1% of observations (replacing outlier payments by the most extreme value that was retained) to confirm that the trends remained.

A two-tailed *P* value of <0.05 was considered significant for all tests, except for when evaluating nature of payment categories with Bonferroni adjustment for multiple comparisons (see table footnotes). Analyses were performed using SPSS (version 26, IBM Corp., Armonk, NY).

Results

Physician demographics

The cohort of practicing physicians in 2014 included 3,743 ROs, 10,270 MOs, and 99,802 other HBPs. Compared to MOs and HBPs, a greater proportion of ROs male and a greater proportion worked in NCI-designated cancer centers and in settings affiliated with medical schools. RO was also characterized by a greater proportion of physicians with fewer than 10 years in practice and a smaller proportion of physicians with over 30 years in practice (Table 1).

Overall physician payments between 2014–2018

Among practicing ROs, 3,379 (90.3%) received at least one payment during the study period, for a total of 106,930 payments valued at \$40.8 million. Among other physicians, 9,651 (94.0%) of MOs and 69,575 (69.7%) of HBPs received at least one payment during the study period, for a total of 1.7 million payments valued at \$347 million and 2.3 million payments valued at \$437 million, respectively. The cumulative median value of payments per individual during the 5-year period was \$604 (IQR: 206, 2144) for ROs, \$3,962 (IQR: 743, 15652) for MOs, and \$212 (IQR: 67, 966) for other HBPs (Table 2). Of all physicians receiving payments, 297 (7.9%) ROs, 3,097 (30.2%) MOs, and 4,058 (4.1%) other HBPs received a cumulative value of payments greater than \$10,000. Of note, after removing a \$16

million outlier payment to a RO in 2018, the mean value of payments for ROs in 2018 was \$2,524 (SD: 17158).

Trends in general payments between 2014–2018

Between 2014 and 2018, the proportion of ROs receiving payments increased by 2.7% annually on average (CI: 0.9, 4.7; $P=0.004$). ROs per-physician number and value of payments increased modestly as well. In contrast, the proportion of MOs and other HBPs receiving payments decreased by -2.2% (CI: $-3.4, -1.0$; $P<0.001$) and -3.4% (CI: $-3.8, -3.1$; $P<0.001$), annually on average, respectively. Similarly, the per-physician number of payments increased among MOs and HBPs, and value of payments increased modestly for MOs and decreased for HBPs (Table 3). Repeating per-physician value of payment analyses using winsorized values to address outliers did not qualitatively affect our findings.

Distribution and trends in the value of general payments by nature of payment between 2014–2018

Between 2014–2018, the value of payments to ROs in the form of accredited education, consulting, and entertainment, meals, travel/lodging, and gifts increased over time. For MOs and HBPs, consulting payments similarly increased in value, while entertainment, meals, travel/lodging, and gifts remained stable or decreased. Between 2014–2018, over 90% of industry payments to both ROs, MOs and other HBPs were in the form of entertainment, meals, travel/lodging, or gifts. However, the value of these payments constituted less than a quarter of the total value of payments. For ROs, investment interests/royalties constituted the majority of the value of payments over time, while non-accredited education constituted the majority of value for MOs and other HBPs (Table 4). If the single outlier payment (\$16 million) to a RO for investment, royalty or licensing fees were removed, ROs would similarly have a majority of payments in the non-accredited education category.

Adjusted trends in radiation oncologists and medical oncologists receiving payments and total per physician value of payments

After adjusting for physician and practice characteristics, the estimated proportion of ROs receiving payments was found to have increased since the inception of Open Payments (OR 1.03, CI: 1.01, 1.05, $P=0.004$) as compared with MOs, where the proportion decreased (OR 0.98; CI: 0.96, 0.99; $P<0.001$). ROs were more likely to receive payments if they were male, mid-career, or practicing in a setting not affiliated with a medical school or an NCI-designated cancer center. The value of payments accepted by ROs were higher for males, for physicians practicing in high-spending regions, and those practicing in settings affiliated with medical schools or NCI-designated cancer centers (Table 5). In comparison, MOs were more likely to accept payments if they were male, mid- to late-career, and in a hospital-affiliated practice. The value of payments accepted by MOs were higher for males, for mid-career physicians, those in high-spending regions, and those affiliated with hospitals, but especially those that were NCI-designated.

Top 10 companies with general payments to practicing radiation oncologists

Between 2014–2018, the top company supplying payments to practicing ROs was Boston Scientific Corporation, due to a \$15 million general payment in 2018 to a single RO for a hydrogel spacer technology. Other than this single interaction, Boston Scientific Corporation had relatively low payments to ROs during this time period. ROs accepted over \$6 million in payments for a total of 24,327 payments together from Bayer Healthcare Pharmaceuticals, AstraZeneca Pharmaceuticals, and E.R. Squibb related to oncologic therapeutics, largely in the class of immunotherapies and small molecules. Varian Medical Systems, Inc. payments related to linear accelerators and proton therapy cyclotrons represented a top proportion of payments totaling \$2.7 million in 8,547 payments. INSYS Therapeutics (INSYS), Novocure, and iCAD all made substantial payments (\$2.0 million in 9,051 payments, \$1.2 million in 4,901 payments, and \$1.2 million in 568 payments, respectively) for opioids/cannabinoids, alternating electric field therapy, and electronic brachytherapy controllers, respectively. Amendia made two payments totaling over \$1 million to ROs during this time period for as-yet undisclosed ownership interests (Table 6).

Discussion

Open Payments data has shed new light on growing industry interactions with ROs, with the total value of payments to ROs surpassing \$40 million since the inception of this national transparency database. Our study demonstrates that payments from industry to physicians are exceedingly common in the field of RO, with most of these payments being of smaller value (<\$10,000 in total). We found important differences in trends over time distinguishing ROs from other physicians. Among ROs, industry payments have become more common, more frequent, and of increasing value since the inception of Open Payments. This is in contrast to MOs and HBPs for which the proportion of physicians accepting payments are decreasing, while the value of payments has increased. With that said, the annual number and value of payments to individual ROs is roughly a quarter that of MOs, consistent with other studies that have discussed differences between high volume, highly profitable pharmaceutical products marketed to MOs and technologies and more limited pharmaceutical products marketed to ROs^{8,24–27}.

These findings merit closer examination²⁹. It is surprising that while a greater proportion of ROs are accepting payments, fewer MOs and HBPs are engaging with industry. Investigation into the reasons for increasing interactions with industry among ROs is needed. Changes in industry approaches to targeted marketing towards RO may be shifting in light of evolving developments in oncologic care^{29,30}. It may also be that awareness or interpretation of ethical standards governing industry-physician relationships is different or less acute in RO compared to these other specialties, and ROs may be more likely to believe that they are immune to influence from industry,³¹ especially since the value of payments received by ROs is significantly less than that of their MO counterparts. More, organizations and other entities in the field of RO may not be utilizing the data available in Open Payments. By comparison, the American Society of Clinical Oncology that largely represents MOs in the US now requests that individuals review and provide a link to their Open Payments record in their conflict of interest disclosure, though this action remains optional³². These various

factors may be limiting the impact of Open Payments in RO. Our data also illustrate that the field of RO overall has experienced an increase in payments in the form of entertainment meals, travel/lodging, or gifts, which are widely considered inappropriate payments²⁸, as compared to MO and HBPs where these payments are stable or decreasing. In all three specialty groups we found increasing values are being directed towards consulting, which may represent a positive change if this activity is related to scientific activities as opposed to marketing²⁸, though our data does not distinguish the type of consulting engaged in.

Our study also identified large cumulative payments from several companies deserving attention. For instance, iCAD made \$1.2 million in payments to ROs for an electronic brachytherapy controller, the applications of which have no randomized prospective studies with long-term follow up supporting their use.⁸ These payments were highest prior to 2016, when reimbursement for electronic brachytherapy was overvalued, leading to rapid adoption.³³ This example is consistent with studies showing that industry promotion often does not correspond to delivery of high-value care³⁴. ROs also received substantial payments from companies that produce oncologic pharmaceuticals, specifically expensive³⁵ and profitable⁴ immunotherapies and targeted therapies, an area of increasing market value amongst pharmaceutical companies³. This is important in the context of ROs' participation in clinical practice guidelines, tumor boards, and editorial boards of major journals, even if their scope of practice in the United States does not generally include the actual prescription of oncologic pharmaceuticals^{25,36,37}. Substantial company payments were less frequently comprised of a high-value payment to an individual physician related to ownership, royalties or investments, such as the single ownership interest payment totaling \$16 million from Boston Scientific Corporation related to the purchase of Augmenix. While it is important to note that these interactions represent legitimate business transactions, these relationships too introduce conflicts of interest with high potential for undue influence⁵.

With that said, ROs regularly medically manage patient symptoms related to their cancer diagnoses and treatments. ROs received over \$2 million from INSYs primarily for sublingual fentanyl, consistent with other data about the magnitude of non-research opioid-related payments to physicians over this time period³⁸. Notably, INSYs has recently been involved in various legal actions stemming from potential illegal conduct in the promotion of this medication to physicians³⁹. Not only have opioid-related marketing and payments been shown to be associated with opioid prescribing; they have also, more significantly, been linked to deaths from opioid overdoses⁴⁰. As opioid prescribers, radiation oncologists should closely consider the implications of opioid marketing for prescribing practices, given the potentially grave impact on patient outcomes.

Strengths of this study include our ability to match payments to a national cohort of physicians to evaluate physician-level changes in general payments over a five-year period. However, our findings must be viewed in light of several limitations. There may be inaccuracies inherent to the Open Payments and NPPES databases, including errors in reporting or classification of payments. Open Payments may also include payments that are later disputed, though only 6,207 (<0.01%) of a total 60.66 million payments reported to Open Payments were disputed. Additionally, the retrospective nature of our study results in unavoidable confounding. Also, our study does not account for potential changes driven by

industry shifts in marketing³. Open Payments does not include all transactions with exclusions of payments less than \$10, product samples, patient-directed educational materials, or rebates/discounts, and has not yet required reporting of payments to other provider types such as physicists, physician assistants or nurse practitioners. In addition, we did not examine research payments, which represent a significant source of industry investment in physicians and a source of broad influence in healthcare; this deserves its own line of inquiry. Therefore, this analysis likely underestimates the prevalence of industry relationships with health care providers and radiation oncologists in particular.

Conclusions

Since the inception of Open Payments, industry payments to practicing radiation oncologists have become more common, more frequent, and of increasing value. This is in contrast to decreasing trends in such payments among other similar medical specialties. Furthermore, among ROs there have not been large shifts away from inappropriate relationships overall. The reasons for these trends deserve further exploration but may relate to lack of awareness of or interest in these data within the field of radiation oncology. Given the significant influence of financial conflicts of interest on physician practice, we hope these findings will prompt radiation oncologists to better address their financial relationships with industry moving forward.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data sharing statement: Research data are publicly available at <https://www.cms.gov/OpenPayments/Explore-the-Data/Dataset-Downloads>, <https://www.cms.gov/Regulations-and-Guidance/Administrative-Simplification/NationalProvIdentStand/DataDissemination>, <https://data.medicare.gov/data/physician-compare>, and by request at <https://healthcaredelivery.cancer.gov/seermedicare/aboutdata/provider.html>.

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Characteristics of a 2014 cohort of practicing radiation oncologists, medical oncologists and other hospital-based physicians in the US

Table 1.

2014 Physician Compare Cohort						
	Radiation Oncologists		Medical Oncologists		Other Hospital-Based Physicians	
	No.	%	No.	%	No.	%
No. of physicians	3,743	100.0%	10,270	100.0%	99,802	100.0%
Gender						
Female	992	26.5%	3,374	32.9%	26,880	26.9%
Male	2,751	73.5%	6,896	67.1%	72,922	73.1%
Years in Practice						
<10	195	5.2%	118	1.1%	6,126	6.1%
10–19	1,187	31.7%	2,966	28.9%	33,519	33.6%
20–29	983	26.3%	3,050	29.7%	27,490	27.5%
>=30	1,378	36.8%	4,136	40.3%	32,677	32.7%
Practice HRR Spending						
Low	365	9.8%	908	8.8%	9,841	9.9%
Average	2,046	54.7%	5,393	52.5%	54,109	54.2%
High	1,332	35.6%	3,969	38.6%	35,852	35.9%
Practice Setting						
Hospital, No/Unknown Affiliation	620	16.6%	1,455	14.2%	19,414	19.5%
Hospital, Medical School Affiliated	1,827	48.8%	5,462	53.2%	54,812	54.9%
Hospital, Medical School Affiliated, NCI Designated	702	18.8%	2,448	23.8%	11,440	11.5%
Not Hospital Affiliated	594	15.9%	905	8.8%	14,136	14.2%

Abbreviations: No., number; HRR, hospital referral region; NCI, National Cancer Institute.

The estimated total number of physicians in each specialty in 2014 determined as per the National Plan and Provider Enumeration System (NPPES) database. Practicing physicians were determined by participation in Physician Compare, a Centers for Medicare & Medicaid Services (CMS) quality database that includes all physicians receiving Medicare payments. Specialty group was determined by physician taxonomy and hospital-based physicians were determined per Medicare Data on Provider Practice and Specialty taxonomy classification. Gender and years in practice were reported in the Physician Compare database. To account for regional variation in physician practice setting and spending, we linked NPPES physician practice zip code to Dartmouth Atlas HRR and corresponding total price-, age-, sex-, and race-adjusted Medicare spending per beneficiary. We categorized practice HRR into three spending groups by dividing per-beneficiary spending into quintiles then sub-grouping into tertiles (low, average, and high) with the lowest quintile (< 20th percentile) and highest quintile (>80th percentile) as the distinct low and high categories, respectively. To account for practice-level factors, we linked Physician Compare hospital affiliation data to the NCI SEER-Medicare Hospital File to determine medical school affiliation and NCI designation (clinical or comprehensive).

* Chi-square test

General payments to practicing radiation oncologists, medical oncologists and other hospital-based physicians in the US*, 2014–2018

Specialty Group	2014	2015	2016	2017	2018	Cumulative (all years combined)
Radiation Oncologists						
Physicians receiving general payment(s) (%), [†] no. [N=3,743]	2,314 (61.8)	2,440 (65.2)	2,426 (64.8)	2,493 (66.6)	2,403 (64.2)	3,379 (90.3)
Value of payments [‡] , USD	\$3,507,972	\$5,791,188	\$5,264,122	\$5,101,660	\$21,093,209	\$40,758,149
Number of payments, no.	17,219	20,714	23,022	23,351	22,624	106,930
Median per-physician value of general payments (IQR), USD	\$134 (44, 367)	\$150 (52, 419)	\$159 (59, 526)	\$146 (49, 480)	\$152 (45, 474)	\$604 (206, 2144)
Mean per-physician value of general payments (SD), USD	\$1,516 (9760)	\$2,373 (20698)	\$2,170 (17590)	\$2,046 (10173)	\$8,779 (307069)	\$12,062 (262006)
Median per-physician number of general payments (IQR), no.	3 (1, 8)	4 (2, 9)	4 (2, 11)	4 (2, 10)	4 (2, 10)	12 (5, 32)
Mean per-physician number of general payments (SD), No.	7 (12)	8 (14)	9 (15)	9 (15)	9 (16)	32 (57)
Medical Oncologists						
Physicians receiving general payment(s) (%), [†] no. [N=10,270]	8,081 (78.7)	8,116 (79.0)	7,993 (77.8)	7,925 (77.2)	7,978 (77.7)	9,651 (94.0)
Value of payments [‡] , USD	\$55,506,615	\$63,883,350	\$74,588,744	\$77,681,989	\$75,210,414	\$346,871,112
Number of payments, no.	293,955	322,158	350,998	363,653	352,483	1,683,247
Median per-physician value of general payments (Range), USD	\$778 (182, 2844)	\$790 (171, 3252)	\$923 (187, 4062)	\$953 (171, 4424)	\$824 (147, 4016)	\$3,962 (743, 15652)
Mean per-physician value of general payments (SD), USD	\$6,869 (26211)	\$7,871 (28004)	\$9,332 (36606)	\$9,802 (34787)	\$9,427 (33439)	\$35,941 (129326)
Median per-physician number of general payments (IQR), no.	14 (4, 50)	15 (4, 54)	17 (4, 62)	17 (4, 64)	15 (4, 60)	57 (12, 225)
Mean per-physician number of general payments (SD), No.	36 (51)	40 (57)	44 (61)	46 (65)	44 (64)	174 (265)
Other Hospital-Based Physicians						
Physicians receiving general payment(s) (%), [†] no. [N=99,802]	40,680 (40.8)	41,046 (41.1)	41,106 (41.2)	39,088 (39.2)	37,467 (37.5)	69,575 (69.7)
Value of payments [‡] , USD	\$78,255,389	\$88,415,352	\$90,595,115	\$86,909,551	\$92,908,387	\$437,083,793
Number of payments, no.	405,449	440,996	489,381	489,207	450,444	2,275,477
Median per-physician value of general payments (Range), USD	\$106 (29, 343)	\$109 (32, 362)	\$111 (32, 379)	\$107 (30, 378)	\$105 (29, 360)	\$212 (67, 966)
Mean per-physician value of general payments (SD), USD	\$1,924 (20131)	\$2,154 (23625)	\$2,204 (24161)	\$2,223 (21975)	\$2,480 (37589)	\$6,282 (75983)
Median per-physician number of general payments (IQR), no.	2 (1, 8)	3 (1, 8)	3 (1, 8)	3 (1, 8)	2 (1, 8)	5 (2, 17)
Mean per-physician number of general payments (SD), No.	10 (23)	11 (25)	12 (28)	13 (30)	12 (29)	33 (98)

Abbreviations: CI, confidence interval; no., number; USD, 2014 United States dollars; SD, standard deviation.

Table 2.

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* The number of physicians in the US was determined using the Centers for Medicare & Medicaid Services (CMS) National Plan and Provider Enumeration System (NPPES) database and includes a nationally representative cohort of physicians in 2014. Practicing physicians were determined by inclusion in Physician Compare, a CMS quality database that includes all physicians receiving Medicare payments.

[†] Based on individual allopathic and osteopathic physicians in Open Payments receiving a general industry payment between January 1, 2014 and December 31, 2018, compared to the estimated total number of allopathic and osteopathic physicians in a 2014 cohort as per the NPPES and Physician Compare databases.

[‡] Total value of general payments to individual physicians as reported to Open Payments, in adjusted 2014 US dollars.

Table 3. Trends in general payments to practicing radiation oncologists, medical oncologists and other hospital-based physicians in the US^a, 2014–2018

Specialty Group	Overall estimates, % or median (IQR)	Annual % difference [‡] (95% CI)	P-value
Radiation Oncologists			
Annual proportion of physicians receiving general payment(s), % ^b [N=3,743]	64.5% (NA)	+2.7% (0.9, 4.7)	0.004 [*]
Annual per-physician number of payments, no.	4 (2, 9)	+6.5% (4.4, 8.7)	<0.001 ^{**}
Annual per-physician value of general payments, USD	\$148 (49, 449)	+4.3% (2.4, 6.3)	<0.001 ⁺
Medical Oncologists			
Annual proportion of physicians receiving general payment(s) (% ^b) [N=10,270]	78.1% (NA)	-2.2% (-3.4, -1.0)	<0.001 [*]
Annual per-physician number of payments, no.	15 (4, 58)	+5.4% (4.6, 6.2)	<0.001 ^{**}
Annual per-physician value of general payments, USD	\$849 (171, 3638)	+1.7 (0.6, 2.7)	0.001 ⁺
Other Hospital-Based Physicians			
Annual proportion of physicians receiving general payment(s) (% ^b) [N=99,802]	40.0% (NA)	-3.4% (-3.8, -3.1)	<0.001 [*]
Annual per-physician number of payments, no.	3 (1, 8)	+3.7% (3.1, 4.3)	<0.001 ^{**}
Annual per-physician value of general payments, USD	\$108 (30, 365)	-2.0% (2.4, 1.5)	<0.001 ⁺
Medical Oncologists			
Annual proportion of physicians receiving general payment(s), % ^b [N=3,743]	64.5% (NA)	+2.7% (0.9, 4.7)	0.004 [*]
Annual per-physician number of payments, no.	4 (2, 9)	+6.5% (4.4, 8.7)	<0.001 ^{**}
Annual per-physician value of general payments, USD	\$148 (49, 449)	+4.3% (2.4, 6.3)	<0.001 ⁺
Other Hospital-Based Physicians			
Annual proportion of physicians receiving general payment(s) (% ^b) [N=10,270]	78.1% (NA)	-2.2% (-3.4, -1.0)	<0.001 [*]
Annual per-physician number of payments, no.	15 (4, 58)	+5.4% (4.6, 6.2)	<0.001 ^{**}
Annual per-physician value of general payments, USD	\$849 (171, 3638)	+1.7 (0.6, 2.7)	0.001 ⁺
Other Hospital-Based Physicians			
Annual proportion of physicians receiving general payment(s) (% ^b) [N=99,802]	40.0% (NA)	-3.4% (-3.8, -3.1)	<0.001 [*]
Annual per-physician number of payments, no.	3 (1, 8)	+3.7% (3.1, 4.3)	<0.001 ^{**}
Annual per-physician value of general payments, USD	\$108 (30, 365)	-2.0% (-2.4, -1.5)	<0.001 ⁺

Abbreviations: CI, confidence interval; IQR, interquartile range; no., number; USD, 2014 United States dollars; SD, standard deviation.

* The number of physicians in the US was determined using the CMS National Plan and Provider Enumeration System (NPPES) database and includes a nationally representative cohort of physicians practicing in 2014. Practicing physicians were determined by inclusion in Physician Compare, a CMS quality database that includes all physicians receiving Medicare payments.

[†] Based on individual allopathic and osteopathic physicians in Open Payments receiving a general industry payment between January 1, 2014 and December 31, 2018, compared to the estimated total number of allopathic and osteopathic physicians in a 2014 cohort as per the NPPES database.

[‡] GEE logistic regression.

[§] GEE Poisson regression.

[∕] GEE linear regression (gamma distribution, log transformed).

Table 4.

Distribution and trends in the value of general payments to a national cohort of practicing radiation oncologists, medical oncologists and other hospital-based physicians in the US* by nature of payment, 2014–2018

Specialty and Nature of Payment	Number of Payments (%), all years	Total Value of Payments, all years (%), USD	Overall Annual Median Value, IQR	Estimated annual % difference ^b (95% CI)	P value ^c
Radiation Oncology					
Accredited Education	33 (0.03)	\$36,363 (0.1)	\$500 (125, 2475)	164% (111, 230)	<0.001
Charity	3 (0.003)	\$4,189 (0.01)	\$1,485 (1213, 1200)	-8% (-11, -5)	<0.001
Consulting	1,791 (1.7)	\$7,877,223 (19.3)	\$3,710 (1300, 7467)	13% (4, 23)	0.003
Entertainment, meals, travel/todging, or gifts	101,170 (94.6)	\$6,617,127 (16.2)	\$138 (47, 377)	3% (1, 4)	0.001
Investment interest, royalty or licensing fees	67 (0.1)	\$17,909,211 (43.9)	\$34,288 (9863, 200,593)	34% (-13, 108)	0.19
Non-accredited education	3,866 (3.6)	\$8,314,029 (20.4)	\$150 (22, 2635)	-1% (-10, 10)	0.90
Medical Oncology					
Accredited Education	120 (0.01)	\$403,172 (0.1)	\$1,364 (465, 3942)	-12% (-35, 19)	0.40
Charity	21 (0.001)	\$263,415 (0.1)	\$939 (572, 29100)	2% (-14, 20)	0.83
Consulting	43,513 (2.6)	\$100,906,713 (29.1)	\$3,800 (1500, 9277)	14% (12, 15)	<0.001
Entertainment, meals, travel/todging, or gifts	1,521,773 (90.4)	\$82,545,195 (23.8)	\$614 (147, 1789)	1% (0, 2)	0.05
Investment interest, royalty or licensing fees	57 (0.003)	\$4,535,207 (1.3)	\$37,198 (449, 293870)	20% (-36, 126)	0.57
Non-accredited education	117,763 (7.0)	\$158,217,409 (45.6)	\$114 (43, 1411)	-5% (-6, -3)	<0.001
Other Hospital-Based Physicians					
Accredited Education	338 (0.01)	\$1,420,963 (0.3)	\$3,200 (1500, 8989)	1% (-15, 22)	0.87
Charity	31 (0.001)	\$121,702 (0.03)	\$1,000 (141, 4954)	-71% (-91, -8)	0.04
Consulting	38,877 (1.7)	\$111,941,692 (25.6)	\$3,117 (900, 9284)	7% (4, 10)	<0.001
Entertainment, meals, travel/todging, or gifts	2,130,543 (93.6)	\$107,094,576 (24.5)	\$103 (30, 312)	-2% (-2, -1)	<0.001
Investment interest, royalty or licensing fees	1,335 (0.1)	\$56,129,272 (12.8)	\$25,354 (4268, 100136)	-19% (-26, -12)	<0.001
Non-accredited education	104,353 (4.6)	\$160,375,588 (36.7)	\$162 (21, 3355)	-1% (-4, 2)	0.52

Abbreviations: CI, confidence interval; no., number; IQR, interquartile range; USD, 2014 United States dollars.

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* Physicians in the US were determined using the Centers for Medicare & Medicaid Services (CMS) National Plan and Provider Enumeration System database and includes a nationally representative cohort of physicians in 2014. Practicing physicians were determined by inclusion in Physician Compare, a CMS quality database that includes all physicians receiving Medicare payments.

† Using GEE linear regression (gamma distribution with log transformation).

‡ Bonferroni corrected P value <0.004 significant.

Table 5.

Adjusted trends in percentages physicians receiving general payments, and total value of general payments over time for practicing radiation oncologists and other physicians between 2014–2018

Co-variable	Radiation Oncology				Medical Oncology			
	Physicians receiving general payments	Total per-physician annual value of payments	Estimated % difference [‡] , USD (95% CI)	P value	Physicians receiving general payments	Total per-physician annual value of payments	Estimated % difference [‡] , USD (95% CI)	P value
Year	1.03 (1.01, 1.05)	0.004	4% (2, 6)	<0.001	0.98 (0.96, 0.99)	<0.001	1% (0, 2)	0.01
Gender								
Female	0.68 (0.62, 0.76)	<0.001	-36% (-43, -30)	<0.001	0.64 (0.59, 0.69)	<0.001	-51% (-54, -46)	<0.001
Male	1 (reference)		reference		1 (reference)		reference	
Years in practice								
<10	1.02 (0.88, 1.18)	0.832	18% (2, 36)	0.02	0.68 (0.60, 0.77)	<0.001	-11% (-22, 1)	0.06
10–19	1.47 (1.27, 1.69)	<0.001	38% (20, 59)	<0.001	1.00 (0.91, 1.11)	0.94	21% (9, 34)	<0.001
20–29	1.35 (1.17, 1.54)	<0.001	20% (5, 36)	0.008	1.04 (0.94, 1.16)	0.44	27% (14, 41)	<0.001
>=30	1 (reference)		reference		1 (reference)		reference	
Practice HRR spending								
Low spending	0.90 (0.75, 1.08)	0.24	-34% (-45, -22)	<0.001	0.59 (0.51, 0.67)	<0.001	-61% (-65, -55)	<0.001
Average spending	0.98 (0.88, 1.08)	0.66	-19% (-27, -10)	<0.001	0.85 (0.79, 0.92)	<0.001	-35% (-40, -29)	<0.001
High spending	1 (reference)		reference		1 (reference)		reference	
Practice Setting								
Hospital, Unaffiliated or Unknown Affiliation	1.27 (1.06, 1.51)	0.008	-21% (-33, -7)	0.005	5.78 (4.96, 6.73)	<0.001	57% (33, 84)	<0.001
Hospital, Medical School Affiliated	1.10 (0.96, 1.28)	0.18	-9% (-21, 4)	0.18	4.10 (3.65, 4.61)	<0.001	84% (59, 113)	<0.001
Hospital, Medical School Affiliated, NCI Designated	0.53 (0.45, 0.62)	<0.001	109% (73, 153)	<0.001	1.99 (1.77, 2.25)	<0.001	210% (162, 266)	<0.001
Not Hospital Affiliated	1 (reference)		reference		1 (reference)		reference	

Abbreviations: CI, confidence interval; HRR, Hospital Referral, Region; OR, odds ratio; NCI, National Cancer Institute.

*The odds ratio represents the exponent of the estimated percentage of physicians receiving one or more payments compared to the reference group.

The value of payments was calculated using a gamma generalized linear regression of log-transformed annual per-physician mean value of general payments. The estimated annual % difference (B coefficient) of the dependent variable can be interpreted as the estimated difference in the mean outcome either by year (continuous) or from the reference group for any variable.

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Table 6. Payments from the top 10 companies with general payments to practicing radiation oncologists, 2014–2018

Company Name	Number of Payments, all years	Total Value of General Payments, USD					Top Product(s)	
		2014	2015	2016	2017	2018		all years
Boston Scientific Corporation	181	\$1,075	\$1,553	\$21,530	\$6,827	\$17,672,413	\$17,703,399	includes Augmenix purchase and ownership interest payment for hydrogel spacer
Bayer HealthCare Pharmaceuticals Inc.	9,988	\$694,735	\$573,046	\$766,780	\$419,337	\$322,446	\$2,776,344	radium Ra 223 dicholoride, regorafenib, sorafenib
Varian Medical Systems, Inc.	8,547	\$287,845	\$445,503	\$948,593	\$548,928	\$461,806	\$2,692,675	linear accelerator, proton cyclotron
AstraZeneca Pharmaceuticals LP	3,988	\$61,065	\$235,195	\$1,244,666	\$469,598	\$389,660	\$2,400,184	durvalumab, osimertinib, fulvestrant
INSYS Therapeutics, Inc.	9,051	\$134,586	\$500,339	\$880,503	\$411,983	\$109,657	\$2,037,069	fentanyl (sublingual), dronabinol
iCAD, Inc.	568	\$71,578	\$215,003	\$580,642	\$255,366	\$107,286	\$1,229,874	electronic brachytherapy controller
Novocure, Inc.	4,901	\$57,124	\$126,083	\$505,525	\$217,448	\$317,893	\$1,224,074	alternating electric field therapy
Amendia, Inc.	2	\$0	\$0	\$1,066,668	\$0	\$0	\$1,066,668	not identified (ownership interest)
Augmenix, Inc.	2,224	\$0	\$22,314	\$271,603	\$330,682	\$429,424	\$1,054,023	hydrogel spacer
E.R. Squibb & Sons, L.L.C.	10,351	\$229,643	\$151,070	\$254,134	\$233,889	\$120,042	\$988,778	nivolumab, cetuximab, elotuzumab

Abbreviations: USD, 2014 United States dollars. Generic or generalized terms are used for product names.