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Distribution and Patterns of Industry-Related Payments to Oncologists in 2014

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Abstract

Background: Industry-physician collaboration is critical for anticancer therapeutic development, but financial relationships introduce conflicts of interest. We examined the specialty variation and context of physician payments and ownership interest among oncologists.

Methods: We performed a population-based multivariable analysis of 2014 Open Payments reports of industry payments to US physicians matched to physician and practice data, including sex, specialty, practice location, and sole proprietor status. Payment data were aggregated per physician and compared by specialty (medical, radiation, surgical, and nononcology), and practice location linked with spending level (low, average, and high). Primary outcomes included likelihood, mean annual amount, and number of general payments. Secondary outcomes included likelihood of holding ownership interests and receipt of royalty/license payments. Estimates for each outcome were determined using multivariable models, including logistic regression for likelihood and linear regression with gamma distribution and log-link for value, adjusted for physician specialty, sex, sole proprietor status, and practice spending. All statistical tests were two-sided.

Results: In 2014, there were 883 438 physicians, including 22 712 oncologists, licensed to practice in the United States. Among oncology specialties, 52.4% to 63.0% of physicians received a general payment in 2014, totaling \$76 million, \$4 million, and \$5 million to medical, radiation, and surgical oncology, respectively. The median annual per-physician payment to medical oncologists was \$632 (IQR = 136–2500), compared with \$124 (IQR = 39–323) in radiation oncology and \$250 (IQR = 84–1369) in surgical oncology. After controlling for physician and practice characteristics, oncologists were 1.09 to 1.75 times as likely to receive a general payment compared with nononcologists (overall $P < .001$). There was a 67.6% difference (95% confidence interval [CI] = 63.6 to 71.5, $P < .001$) in the mean annual value of payments between medical oncology and nononcology specialties (vs -92.7% , 95%CI = -100.2 to -85.0 , $P < .001$) for radiation oncology). Medical and radiation oncologists were more likely to hold ownership interest (adjusted OR = 3.72, 95% CI = 3.22 to 4.27, and 2.27, 95% CI = 1.65 to 3.03, respectively, $P < .001$ both comparisons).

Conclusions: In 2014, industry-oncologist financial relationships were common, and their impact on oncology practice should be further explored.

Collaboration between oncologists, researchers, and biomedical industries is essential for the development of novel cancer therapeutics (1). However, financial relationships between physicians and industry create conflicts of interest. Whether

industry-related financial conflicts of interest introduce undue influence on physician decision-making and treatment utilization is highly controversial (2–10). This issue has received considerable recent attention with healthcare reform (11),

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specifically in oncology because of concerns over costs of cancer care (12–14).

Prompted by such concerns (2), industry payments to physicians and teaching hospitals are now legally required to be reported (11) to the Open Payments (OP) program, managed by the Centers for Medicare and Medicaid Services (CMS) (15,16). CMS recently released comprehensive nationwide data on industry payments to physicians made between August 1, 2013, and December 31, 2014, including 11.4 million records totaling \$6.5 billion (17). This unprecedented volume of data affords a unique opportunity to examine the extent and magnitude of industry payments to physicians in oncology. Industry-related financial conflicts of interest in oncology, previously assessed through physician surveys/self-report (18–20) and retrospective abstract or publication review, have been shown to impact reporting of cancer research (19,21–23). We present a comprehensive population-based analysis of industry payments to oncologists matched with physician-level data to investigate the distribution and specialty-specific context of these relationships.

Methods

We performed a retrospective, population-based analysis of physicians in CMS' National Plan & Provider Enumeration System (NPPES) database linked to 2014 OP reports of industry payments to US physicians.

Study Population

The study population consisted of physicians in the September 2015 NPPES database, the CMS database against which OP physician records are verified. NPPES provider demographics are collected upon physician enrollment and updated periodically (24). We excluded physicians added to NPPES in 2015. When multiple National Provider Identifiers (NPIs) existed for a single physician, we selected the most recently updated NPI. In order to match practice location to regional spending data, we excluded physicians practicing in other countries, in US territories or minor outlying islands, or in areas where zip code was not assigned to a hospital referral region (HRR) (25). We limited our analyses to doctors in allopathic and osteopathic specialties (excluding other professions such as podiatrists) (24). NPPES includes all physicians reportable to OP with an NPI, therefore we used NPPES specialty data to estimate the number of physicians licensed to practice in the United States (26) subject to OP reporting. OP does not release NPIs (11) or physician demographics beyond name and practice location. Therefore, we matched NPPES and the OP physician supplementary file using text-string identifiers. This process achieved 96% fidelity (657 215 of 684 806 records) for matching the OP physician to his/her NPPES data. See [Supplementary Figure 1](#) (available online) for detailed inclusion/exclusion criteria of the NPPES study population and matched OP physicians.

OP Data Selection

We analyzed the most recent June 30, 2015, release of OP data on industry payments (>\$10 or \$100 in aggregate annually) to physicians made between January 1 and December 31, 2014, linking each record to NPPES data as described above. Data for covered recipient physicians were analyzed, representing any physician or surgeon licensed to practice in the United States,

excluding payments to teaching hospitals. OP excludes physician employees of a reporting entity and medical residents.

Physician and Practice Characteristics

Physician and practice characteristics including sex, specialty classification, status as a sole proprietor (24), and hospital referral region spending level were examined. Specialty classifications were aggregated as follows: medical oncology (hematology/oncology, medical oncology, pediatric hematology/oncology); radiation oncology; surgical oncology (surgical oncology, gynecologic oncology); nononcology specialties (all other specialties).

To account for regional variation in physician practice setting and spending (2), we linked NPPES physician practice zip code to Dartmouth Atlas HRR and corresponding 2012 total price-, age-, sex-, and race-adjusted Medicare spending per beneficiary (25). We categorized practice HRRs into three spending groups by dividing per-beneficiary spending into quintiles then subgrouping into tertiles (low, average, and high), with the lowest quintile ($\leq 20^{\text{th}}$ percentile) and highest quintile ($> 80^{\text{th}}$ percentile) as the distinct low and high categories, respectively (27). NPPES data also includes whether the physician is a sole proprietor (24).

Payment Characteristics

We estimated the percentage of physicians receiving one or more payment(s) in 2014 and characterized the number and value of payments by type (general or research) and specialty classification. Of all reported payments in 2014, 79% (\$2.01 billion of \$2.56 billion) of general payments and 4% (\$127 million of \$3.23 billion) of research payments were attributable to a physician recipient. General payments include all forms of payment other than those classified for research. Research payments are for research activities pursued under a written contract or protocol, including medical research writing or publication (29). We calculated the per-physician annual mean and/or median number and value of general payments using physicians who received general payments as the denominator. We also calculated the distribution and specialty variation by the 'nature' or reason for payment (30) as proportions of the total number and value. We described the top manufacturers and products associated with general payments by total value. Finally, we estimated the percentage of physicians holding ownership interest in 2014 and characterized the number, dollar amount invested, and value of interests. Ownership interests include stocks/stock options, partnership shares, or other financial instruments secured by the reporting entity that were held by physicians or immediate family members (15). Notable exclusions include compensation (until exercised) and interest as part of a retirement plan or publicly traded security/mutual fund. We utilized CMS terms "amount invested" and "value of interest" to describe the original amount of the interest holding and the cumulative value of that ownership interest at the end of the reporting period, respectively. Ownership interests valued at \$0 were removed from the analyses.

Outcomes

Primary outcomes included percentage of physicians receiving a general payment, and total value and number of general payments. Value of payment data was highly skewed, so we used

logarithmic transformation to normalize the distribution for the univariate analysis and a gamma distribution and log-link approach for the multivariable analyses (31). Secondary outcomes included percentage of physicians receiving royalty/licensing payments and the percentage of physicians holding ownership interests.

Analyses

Characteristics of physicians, payments, and ownership interests were compared between specialty classifications using Pearson's chi-squared (or Fisher's exact test) and the Kruskal-Wallis test (30). Given potential differences in physician and practice characteristics across specialties, we performed univariate and multivariable analyses to determine predictors of the association between specialty and physician payments and ownership interests. Generalized unadjusted logistic regression models were used to examine the association between each characteristic and the likelihood of physicians receiving general payments, royalty/license payments, or holding ownership interests. Generalized unadjusted regression models were used to examine the association of the log of the mean value of general payments and each physician/practice characteristic. Generalized unadjusted negative binomial regression models examined the association between each characteristic and the per-physician annual number of general payments. Adjusted estimates were then determined for each outcome using multivariable models, which included physician specialty classification, sex, sole proprietor status, and practice HRR spending as covariables. The multivariable model for mean value of general payments was estimated using a generalized linear model with gamma distribution and log-link (31).

A two-tailed *P* value of less than .05 was considered statistically significant for all tests. Analyses were performed using SPSS (version 23, IBM Corp, Armonk, NY).

Results

Study Population

An estimated 883 438 physicians, including 22 712 in oncology specialties, were licensed to practice in the United States in 2014.

Physician and Practice Characteristics

Table 1 shows physician demographics by specialty classification. Male physicians predominate in all specialty classifications. A minority of physicians were sole proprietors, especially in oncology specialties. The majority of oncology specialists practiced in average HRR regions.

Payment Characteristics

Characteristics of payments by specialty classification are shown in Table 2 and Figure 1. Among oncology specialties, 63.0%, 52.4%, and 58.3% of medical, radiation, and surgical oncologists received a general payment totaling \$76 million, \$4 million, and \$5 million to each specialty, respectively. The median annual per-physician number and value of general payments was highest in medical oncology compared with other specialty types (\$632, IQR = 136–2500, vs \$124, IQR = 39–323, in radiation oncology, \$250, IQR = 84–1369, in surgical oncology). As shown in Figure 1, the median annual per-physician value of payments was skewed, indicating that few outlier physicians received large sums, especially in medical oncology. The proportion of physicians receiving research payments was 4.8% in medical oncology vs less than 1% in all other specialty classifications. The top three manufacturers and pharmaceuticals by total value of general payments to each oncology specialty are shown in Table 3.

Table 1. US physician and practice characteristics in 2014

Characteristic	Oncology specialties*			Nononcology specialties No. (%)	P†
	Medical oncology No. (%)	Radiation oncology No. (%)	Surgical oncology No. (%)		
US physicians	15 494	4934	2284	860 726	
Sex					
Male	10 424 (67.3)	3628 (73.5)	1497 (65.5)	572 832 (66.6)	<.001
Female	5070 (32.7)	1306 (26.5)	787 (34.5)	287 894 (33.4)	
Practice HRR spending‡					
Low	2415 (15.6)	805 (16.3)	301 (13.2)	137 133 (15.9)	
Average	9790 (63.2)	3008 (61.0)	1419 (62.1)	542 032 (63.0)	<.001
High	3289 (21.2)	1124 (22.7)	564 (24.7)	181 561 (21.1)	
Sole proprietor§					
Yes	2032 (13.1)	613 (12.4)	341 (14.9)	189 867 (22.1)	
No	12 905 (83.3)	4131 (83.7)	1877 (82.2)	627 866 (72.9)	<.001
No response	557 (3.6)	190 (3.9)	66 (2.9)	42 993 (5.0)	

*Specialties are classified by specialty type, including: medical oncology (medical oncology, hematology/oncology, pediatric hematology/oncology); radiation oncology; surgical oncology (surgical oncology, gynecologic oncology); and nononcology (all other specialties). HRR = hospital referral region.

†Reported *P* values are comparing proportions across specialties using Pearson's chi squared test, two-sided.

‡Practice HRR spending groups are based on 2012 Dartmouth Atlas price-, age-, sex-, and race-adjusted mean spending per-beneficiary divided into quintiles then grouped into tertiles (low, average, and high), with the lowest quintile (\leq 20th percentile) and highest quintile ($>$ 80th percentile) as the distinct low and high categories, respectively.

§Per Centers for Medicare and Medicaid Services' National Plan & Provider Enumeration System, a sole proprietor is the sole (the only) owner of a business that is not incorporated (<https://nppes.cms.hhs.gov/NPPES/Help.do?topic=IndProfile>).

Table 2. Industry payments and ownership interests, US physicians in 2014

Report classification	Specialty classification* (n = US physicians)				P†
	Medical oncology (n = 15 494)	Radiation oncology (n = 4934)	Surgical oncology (n = 2284)	Nononcology specialties (n = 860 726)	
General payments					
No. of physicians receiving general payment(s) (%)	9765 (63.0)	2585 (52.4)	1332 (58.3)	422 567 (49.1)	
No. of general payments (% of all general payments)	314 183 (3.4)	17 668 (.2)	13 380 (.1)	8 942 085 (96.3)	
Value of payments (% of total general payment value), \$	75 682 601 (4.4)	4 442 260 (.3)	5 103 033 (.3)	1 628 515 549 (95.0)	
Median annual per-physician number of general payments (IQR)‡	11 (3–43)	3 (1–7)	6 (2–12)	6 (2–21)	<.001
Median annual per-physician value of general payments (IQR)‡, \$	632 (136–2500)	124 (39–323)	250 (84–1369)	193 (57–723)	<.001
Research payments					
No. of physicians receiving research payment(s) (%)	738 (4.8)	11 (.2)	14 (.6)	4443 (.5)	
No. of research payments (% of all research payments)	2138 (8.0)	15 (<.1)	18 (<.1)	24 618 (91.9)	
Value of payments (% of total research payment value), \$	4 334 905 (3.8)	77 419 (.1)	185 165 (.2)	108 156 858 (95.9)	
Ownership interests					
No. of physicians with ownership interest(s) (%)	213 (1.4)	43 (.9)	7 (.3)	3083 (.4)	
No. of ownership interests (% of all ownership interests)	219 (5.9)	45 (1.2)	7 (.2)	3439 (92.7)	
Amount invested (% of total ownership amount), \$	7 209 719 (2.7)	2 280 758 (.8)	66 527 (<.1)	259 331 332 (96.4)	
Value of interest (% of total ownership value), \$	10 796 957 (2.5)	3 383 694 (.8)	624 587 (.1)	420 957 615 (96.6)	

*Specialties are classified by specialty type, including: medical oncology (medical oncology, hematology/oncology, pediatric hematology/oncology); radiation oncology; surgical oncology (surgical oncology, gynecologic oncology); and nononcology (all other specialties). All dollar amounts are 2014 United States dollars. IQR = interquartile range.

†Reported P values are comparing across specialties using the Kruskal-Wallis test, two-sided.

‡Calculation includes only values for those physicians who received a general payment.

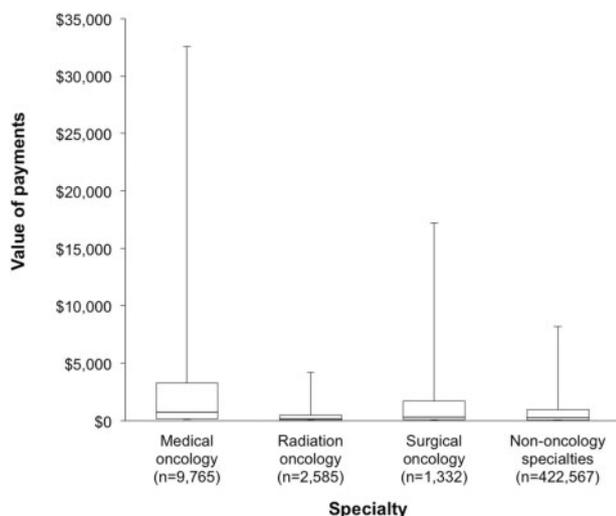


Figure 1. Value of general payments to US physicians in 2014. The value represents the annual per-physician value of payments shown in 2014 US dollars. The box represents the 25th to 75th percentiles, and the whiskers represent the 5th and 95th percentiles.

Figure 2 summarizes the proportion of the annual number and total value of general payments in each nature of payment category, aggregated by oncology specialty classification. Nature of payment by number was largely for food and beverage (82.0%) in oncology overall (Figure 2A). However, by total value, the largest payment categories included nonconsulting/continuing medical education (CME) services, consulting, and travel for all oncology specialties (Figure 2B). Radiation oncology and surgical oncology had a large proportion of value in royalty/license payments (18.8% and 19.3%, respectively, vs <1% for

medical oncology), surgical oncology had a large proportion of payments for education (15.6% vs <1% for medical and radiation oncology), and medical oncology had a large proportion of payments for ownership interest (17.3% vs <1% for radiation and surgical oncology). Proportions of general payments in each nature-of-payment category by number and value were statistically significantly different between oncology specialties ($P < .001$, all comparisons).

Ownership interests by specialty classification are presented in Table 2. The percentage of physicians holding ownership interests ranged from 0.3% to 1.4% in oncology specialties.

Physician Payments and Ownership Interests

Unadjusted analyses of general payment outcomes by specialty classification and other physician demographics are shown in Table 4. The percentage of medical oncologists receiving general payments was higher (63.0%, 95% confidence interval [CI] = 62.3% to 63.8%, $P < .001$) than other specialties. Medical oncologists had a \$3897 higher mean total per-physician annual value of payments (95% CI = 1515 to 6278, $P = .001$) compared with nononcology specialties, while radiation oncologists had a \$2135 lower value (95% CI = -6725 to 2454, $P < .001$). The total per-physician annual number of payments was higher in medical oncology (mean = 32.17, 95% CI = 31.22 to 33.13, $P < .001$), compared with nononcology specialties (mean = 21.16, 95% CI = 21.04 to 21.28, reference group), and lower in both radiation oncology (mean = 6.83, 95% CI = 6.42 to 7.25, $P < .001$) and surgical oncology (mean = 10.05, 95% CI = 9.25 to 10.84, $P < .001$). Male physicians were more likely to receive payments, with higher per-physician annual value and number of payments ($P < .001$, all comparisons). Similar unadjusted analyses of ownership interest payments and royalty/license payments are shown in Table 5.

Table 3. Top payments to oncology specialties in 2014 by manufacturer and by pharmaceutical

Measure	Oncology specialty classification	Manufacturer name (parent company)	Pharmaceutical name	No. of general payments	Total value of general payments, \$
Top 3 per oncology specialty by manufacturer-associated total value of payment					
	Medical oncology	Genentech, Inc. (Roche)†	–	671	13 436 764
		Celgene Corporation*	–	28 850	7 021 681
		Genentech USA, Inc. (Roche)†	–	37 220	5 111 155
	Radiation oncology	C. R. Bard, Inc. & Subsidiaries*	–	81	773 500
		Bayer HealthCare Pharmaceuticals' Inc.*	–	1589	652 166
		Varian Medical Systems, Inc.†	–	1168	304 283
	Surgical oncology	Intuitive Surgical, Inc.†	–	3170	1 295 089
		Stryker Corporation, MI, United States	–	336	1 001 761
		Genentech USA, Inc. (Roche)†	–	951	531 654
Top 3 per oncology specialty by pharmaceutical-associated total value of payment					
	Medical oncology	Millennium Pharmaceuticals, Inc. (Takeda)*	Velcade (bortezomib)	7255	2 117 483
		Genentech, Inc. (Roche)†	Avastin (bevacizumab)	15 065	1 900 159
		Onyx Pharmaceuticals, Inc. (Amgen)†	Kyprolis (carfilzomib)	5569	1 813 092
	Radiation oncology	Bayer HealthCare Pharmaceuticals, Inc.‡	Xofigo (Radium Ra 223 dichloride)	1356	647 911
		ImClone, LLC (Eli Lilly)‡	Erbix (cetuximab)	971	235 517
		Astellas Pharma US, Inc.§	Xtandi (enzalutamide)	311	90 214
	Surgical oncology	Genentech, Inc. (Roche)†	Avastin (bevacizumab)	462	320 028
		Genentech, Inc. (Roche)†	Perjeta (pertuzumab)	220	111 388
		IMClone, LLC (Eli Lilly)‡	Erbix (cetuximab)	244	64 423

All dollar amounts are 2014 United States dollars. – = not applicable; NDC = national drug code.

*MA, United States.

†CA, United States.

‡NJ, United States.

§IL, United States.

||MI, United States.

Adjusted Association Between Specialty Classification and Payments/Ownership Interests

Multivariable models adjusted for specialty classification and physician/practice demographics are presented in Table 6. After controlling for physician and practice characteristics, oncology specialties were between 1.09 and 1.75 times as likely to receive a general payment compared with nononcology specialties (overall $P < .001$). Physicians' sex, non-sole proprietor status, and average or high practice HRR spending were associated with a higher likelihood of general physician payments. Medical oncologists received a greater annual number of general payments compared with nononcology specialties.

Adjusted estimates showed a 67.6% difference (95% CI = 63.6 to 71.5, $P < .001$) in the mean value of payments between medical oncology and nononcology specialties (vs -92.7, 95% CI = -100.2 to -85.0, $P < .001$ for radiation oncology). The annual value of general payments was lower among female physicians and sole proprietors. Medical and radiation oncologists were more likely to have held ownership interest (adjusted OR = 3.72, 95% CI = 3.22 to 4.27 and adjusted OR = 2.27, 95% CI = 1.65 to 3.03, respectively, $P < .001$ both comparisons). Medical and radiation oncologists were less likely to have received a royalty/license payment compared with nononcology specialties. Male physicians had a greater likelihood of receiving royalty/license payments (adjusted OR = 37.37, 95% CI = 25.20 to 58.70, $P < .001$).

Discussion

With CMS' recent release of an unparalleled volume of nationwide industry-physician payment data, there has been

anticipation over the findings and even concern over the interpretation of these payments in oncology (1,32,33). We matched payments to oncologists with physician-level data, showing that financial relationships were common (52%–63%) in 2014 and that payment patterns varied among oncology specialties after controlling for physician and practice characteristics. Medical oncologists were more likely to receive general payments than other oncology specialists and nononcologists, and they tended to interact more frequently with industry with higher per-physician payments. Radiation and surgical oncologists were more likely to receive general payments but tended to receive fewer payments per year compared with nononcologists. Both surgical and radiation oncologists received 19% of general payment value for royalty/license payments. However, after adjusting for physician and practice demographics, medical and radiation oncologists were statistically significantly less likely to receive royalty/license payments compared with nononcologists. Few physicians in 2014 held ownership or investment interests in the biomedical industry.

Prior studies have shown that 36% of abstract authors at annual oncology meetings disclosed financial conflicts of interest (22), underestimating the prevalence of these relationships compared with our findings using nationwide data. Medical oncologists are a likely target for industry spending given their influence over prescribed cancer therapies, and a large proportion of pharmaceutical promotional spending continues to be directed at physicians despite a rise in direct-to-consumer advertising and other forms of promotion (34,35). However, industry spending is also related to medical oncologists' critical role in drug development and translation of new treatments into clinical practice (32,36). In comparison, radiation oncologists

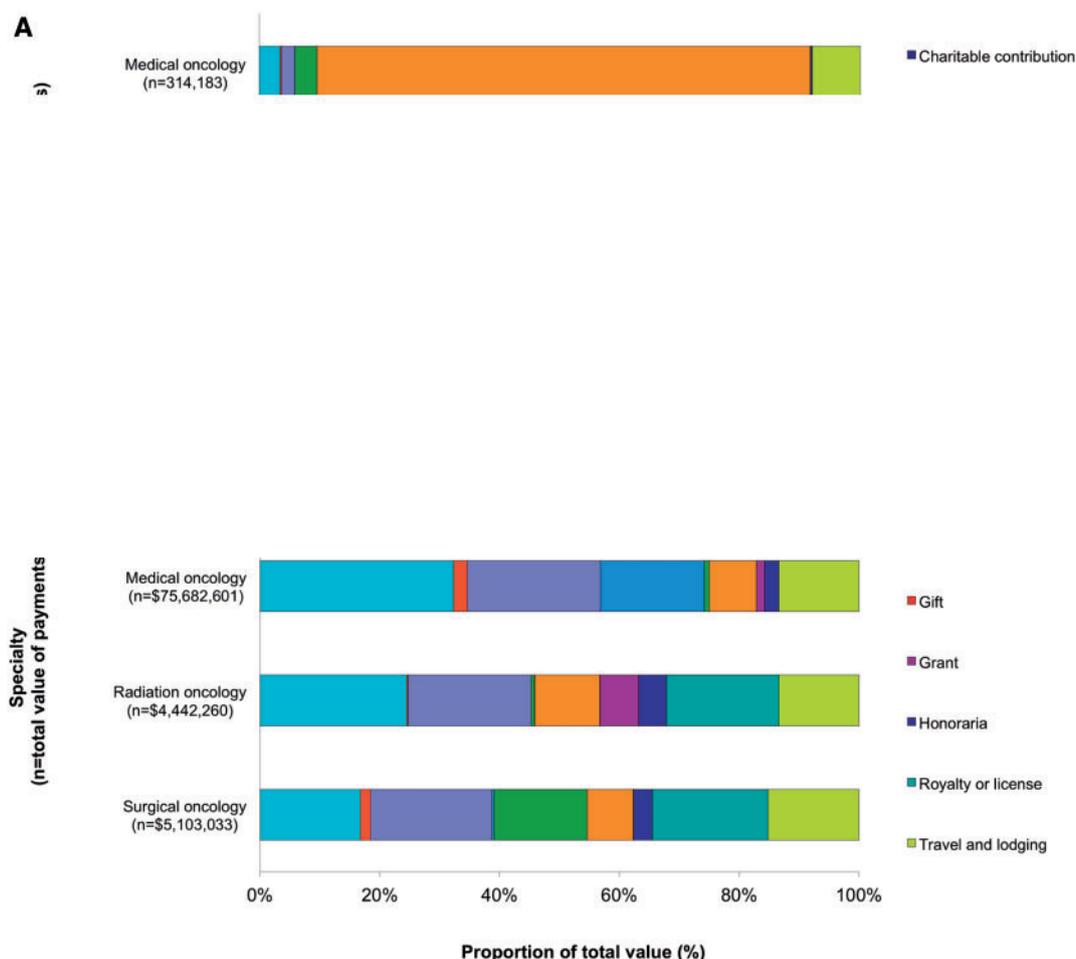


Figure 2. Distribution of the nature of general payments to physicians in the US in 2014 by oncology specialty classification. The figure is based on Open Payments data for industry payments to physicians and surgeons between January 1, 2014, and December 31, 2014, that matched to the National Plan & Provider Enumeration System (NPPES). Values are in 2014 United States dollars. **A)** The number of general payments is depicted, and the bar represents the total number of general payments made during the reporting period for each specialty classification. Each colored component represents the number of general payments made in each nature of payment category. **B)** The total value of general payments is shown. The bar represents the total value of payments made during the reporting period for each specialty classification, and each colored component represents the total value of payments made in each nature-of-payment category. The proportion of general payments in each nature-of-payment category was statistically significantly different between specialty classifications (Fisher's exact test, $P < .001$, two-sided test). CME= continuing medical education; n = the number of physicians in each specialty classification receiving a general payment.

interact with device and drug companies less than their oncology colleagues; this is supported by a recent descriptive study of OP data unadjusted for provider/practice characteristics (37). We also found that both medical and radiation oncologists were less likely to receive royalty/license payments compared with surgical and nononcology specialties, consistent with findings that product development and licensing are important types of industry-physician interaction in surgical specialties (38). Although analyses of potential correlations between OP-reported spending, practice patterns, and healthcare spending are beyond this study's scope, several manufacturers of top-selling cancer therapeutics in 2014 (39,40) were among the top in highest value of payments to oncologists.

Given declines in government-funded research support (17) and the importance of industry-funded cancer research, there is concern about the interpretation of payments for research in oncology, specifically related to clinical trials, medical research writing, and publication costs (1,32). Research payments in OP exclude those associated with proprietary products, which makes analyses difficult. Our study focused on physician-

specific payments, excluding payments to teaching hospitals, which is likely why only 4% of research payments were attributed to a single physician. Research grants are reported as grants under general payments if they are supported by industry gifts to foundations. There is concern that this can create the illusion of a problematic financial relationship between a physician and industry (32). However, only .02% of general payments in 2014 were related to grants.

Previous studies of ownership interest found that less than 1% of authors presenting at annual oncology meetings in 2004 and 2005 disclosed stock ownership, after excluding company employees (18), but researchers with financial interests greater than \$100 000 largely held stock. More recent studies showed that 30% of plenary session abstracts at the American Society for Clinical Oncology (ASCO) annual meeting had an author reporting stock ownership (22), and 14% of authors of cancer clinical practice guidelines and consensus statements reported stock ownership (41). While we found that the prevalence of ownership interest is limited to few physicians, medical and radiation oncologists were two to three times as likely to hold

Table 4. Unadjusted percentages of physicians receiving general payments and annual per-physician value and number of payments in 2014 by specialty classification, sex, practice hospital referral region, and sole proprietor status

Covariable	Physicians receiving general payments				Total per-physician annual value of payments				Total per-physician number of payments				
	No. of US physicians	% receiving payments (95% CI)	OR* (95% CI)	P†	No. of physicians receiving general payments	Mean, \$	(95% CI)	Difference (95% CI), \$	P‡	No. of physicians receiving general payments	Mean (95% CI)	IRR (95% CI)§	P
Specialty classification													
Nononcology specialties	860 726	49.1 (49.0 to 49.2)	1 (Referent)	<.001	422 567	3854	(3494 to 4214)	0 (Referent)	.01	422 567	21.16 (21.04 to 21.28)	1 (Referent)	<.001
Medical oncology	15 494	63.0 (62.3 to 63.8)	1.77 (1.71 to 1.82)	<.001	9765	7750	(5574 to 9926)	3897 (1515 to 6278)	.001	9765	32.17 (31.22 to 33.13)	1.52 (1.49 to 1.55)	<.001
Radiation oncology	4934	52.4 (51.0 to 53.8)	1.14 (1.08 to 1.21)	<.001	2585	1718	(997 to 2440)	-2135 (-6725 to 2454)	<.001	2585	6.83 (6.42 to 7.25)	.32 (.31 to .34)	<.001
Surgical oncology	2284	58.3 (56.3 to 60.3)	1.45 (1.34 to 1.58)	<.001	1332	3831	(2327 to 5335)	-23 (-6407 to 6361)	.98	1332	10.05 (9.25 to 10.84)	.48 (.45 to .50)	<.001
Sex													
Female	295 057	43.4 (43.2 to 43.5)	1 (Referent)	<.001	127 943	1823	(1005 to 2640)	0 (Referent)	<.001	127 943	15.88 (15.71 to 16.05)	1 (Referent)	<.001
Male	588 381	52.4 (52.3 to 52.5)	1.44 (1.43 to 1.45)	<.001	308 306	4802	(4437 to 5167)	2979 (2206 to 3753)	<.001	308 306	23.53 (23.38 to 23.69)	1.48 (1.47 to 1.49)	<.001
Practice HRR spending													
Low spending	140 654	37.4 (37.1 to 37.6)	1 (Referent)	<.001	52 550	4095	(3359 to 4832)	0 (Referent)	.24	52 550	16.04 (15.74 to 16.34)	1 (Referent)	<.001
Average spending	556 249	50.1 (49.9 to 50.2)	1.68 (1.66 to 1.70)	<.001	278 461	4099	(3576 to 4623)	4 (-1102 to 1110)	.99	278 461	21.68 (21.53 to 21.83)	1.34 (1.34 to 1.37)	<.001
High spending	186 535	56.4 (56.2 to 56.6)	2.17 (2.14 to 2.20)	<.001	105 238	3392	(3110 to 3675)	-703 (-1946 to 540)	.08	105 238	22.87 (22.62 to 23.12)	1.41 (1.41 to 1.44)	<.001
Sole proprietor status													
No	646 779	50.3 (50.2 to 50.4)	1 (Referent)	<.001	325 328	4370	(3384 to 4771)	0 (Referent)	.001	325 328	21.64 (21.51 to 21.78)	1 (Referent)	<.001
Yes	192 853	48.3 (48.1 to 48.5)	.92 (.91 to .93)	<.001	93 122	2721	(2434 to 3008)	-1587 (-2451 to -722)	<.001	93 122	20.78 (20.52 to 21.05)	.96 (.95 to .97)	<.001
No No answer	43 806	40.6 (40.2 to 41.1)	.68 (.66 to .69)	<.001	17 799	3319	(2547 to 4091)	-988 (-2779 to 802)	.03	17 799	17.44 (16.90 to 17.98)	.81 (.79 to .82)	<.001

*The odds ratio represents the exponent of the estimated percentage of physicians receiving one or more payments compared with the reference group. All dollar amounts are 2014 United States dollars. CI = confidence interval; HRR = hospital referral region; IRR = incidence rate ratio; OR = odds ratio.

†Generalized unadjusted logistic regression model, two-sided P value.

‡Generalized unadjusted linear regression model of the log of the mean value of payments, two-sided P value.

§The incidence rate ratio represents the exponent of the log of annual per-physician number of payments compared with the reference group.

||Generalized unadjusted negative binomial regression model, two-sided P value.

Table 5. Unadjusted percentages of physicians with ownership interests and receiving royalty/license payment in 2014 by specialty classification, sex, practice hospital referral region, and sole proprietor status*

Covariable	Physicians with ownership interests				Physicians with royalty/license payments			
	No. of US physicians	% with ownership (95% CI)	OR* (95% CI)	P†	No. of US physicians	% with royalty/license payments (95% CI)	OR (95% CI)	P†
Specialty classification				<.001				<.001
Nononcology	860 726	.4 (.4 to .4)	1 (Referent)		860 726	.2 (.2 to .2)	1 (Referent)	
Medical oncology	15 494	1.4 (1.2 to 1.6)	3.88 (3.36 to 4.45)	<.001	15 494	<.1 (<.1 to .1)	.10 (.03 to .27)	<.001
Radiation oncology	4934	.9 (.7 to 1.2)	2.45 (1.78 to 3.26)	<.001	4934	<.1 (<.1 to <.1)	.22 (.04 to .67)	.03
Surgical oncology	2284	.1 (.2 to .6)	.86 (.37 to 1.66)	.68	2284	.2 (.1 to .5)	1.17 (.42 to 2.52)	.73
Sex				<.001				<.001
Female	295 057	.4 (.4 to .5)	1 (Referent)		295 057	<.1 (<.1 to <.1)	1 (Referent)	
Male	588 381	.3 (.2 to .3)	1.73 (1.59 to 1.87)	<.001	588 381	.3 (.3 to .3)	36.57 (24.66 to 57.44)	<.001
Practice HRR spending				<.001				.03
Low spending	140 654	.2 (.2 to .2)	1 (Referent)		140 654	.2 (.1 to .2)	1 (Referent)	
Average spending	556 249	.4 (.4 to .4)	1.89 (1.60 to 2.03)	<.001	556 249	.2 (.2 to .2)	1.13 (.98 to 1.31)	.10
High spending	186 535	.5 (.4 to .5)	2.11 (1.86 to 2.41)	<.001	186 535	.2 (.2 to .2)	1.25 (1.06 to 1.47)	.01
Sole proprietor status				<.001				<.001
No	646 779	.4 (.4 to .5)	1 (Referent)		646 779	.2 (.2 to .2)	1 (Referent)	
Yes	192 853	.3 (.2 to .3)	.64 (.58 to .70)	<.001	192 853	.1 (.1 to .1)	.53 (.46 to .62)	<.001
No response	43 806	.4 (.4 to .5)	.99 (.85 to 1.15)	.88	43 806	.2 (.1 to .2)	.71 (.55 to .91)	.01

*The odds ratio represents the exponent of the estimated percentage of physicians holding ownership interests or receiving one or more payments compared with the reference group. CI = confidence interval; HRR = hospital referral region; OR = odds ratio.

†Generalized unadjusted logistic regression model, two-sided P value.

Table 6. Adjusted percentages of physicians receiving general payments, holding ownership interests, or receiving royalty/license payments and total number and value of general payments in 2014 by specialty classification

Covariable	Physicians receiving general payments		Total per-physician number of payments		Total per-physician annual value of payments		Physicians with ownership interest		Physicians with royalty/license general payments	
	OR* (95% CI)	P†	IRR‡ (95% CI)	P§	% difference (95% CI)	P¶	OR* (95% CI)	P†	OR* (95% CI)	P†
Physicians, No.	883 438		436 249		436 249		883 438		883 438	
Specialty classification		<.001		<.001		<.001		<.001		<.001
Nononcology	1 (Referent)		1 (Referent)		0 (Referent)		1 (Referent)		1 (Referent)	
Medical oncology	1.75 (1.70 to 1.81)	<.001	1.50 (1.47 to 1.53)	<.001	67.6 (63.6 to 71.5)	<.001	3.72 (3.22 to 4.27)	<.001	.10 (.02 to .25)	<.001
Radiation oncology	1.09 (1.03 to 1.16)	.002	.32 (.31 to .33)	<.001	-92.7 (-100.2 to -85.0)	<.001	2.27 (1.65 to 3.03)	<.001	.18 (.03 to .57)	.02
Surgical oncology	1.41 (1.30 to 1.53)	<.001	.47 (.45 to .50)	<.001	.6 (-9.8 to 11.4)	.97	.82 (.35 to 1.59)	.60	1.13 (.40 to 2.44)	.79
Sex		<.001		<.001		<.001		<.001		<.001
Female	1 (Referent)		1 (Referent)		0 (Referent)		1 (Referent)		1 (Referent)	
Male	1.45 (1.43 to 1.46)	<.001	1.48 (1.47 to 1.49)	<.001	99.4 (98.1 to 100.1)	<.001	1.73 (1.59 to 1.88)	<.001	37.37 (25.20 to 58.70)	<.001
Practice HRR spending		<.001		<.001		<.001		<.001		
Low spending	1 (Referent)		1 (Referent)		0 (Referent)		1 (Referent)		1 (Referent)	
Average spending	1.69 (1.67 to 1.71)	<.001	1.34 (1.33 to 1.35)	<.001	-0.6 (-2.5 to 1.2)	.97	1.82 (1.62 to 2.05)	<.001	1.13 (.98 to 1.31)	.10
High spending	2.18 (2.15 to 2.21)	<.001	1.41 (1.40 to 1.43)	<.001	-21.1 (-23.2 to -19.0)	.08	2.15 (1.89 to 2.46)	<.001	1.25 (1.06 to 1.48)	.01
Sole proprietor status		<.001		<.001		<.001		<.001		<.001
No	1 (Referent)		1 (Referent)		0 (Referent)		1 (Referent)		1 (Referent)	
Yes	.88 (.87 to .89)	<.001	.97 (.96 to .97)	<.001	-43.5 (-44.9 to -42.0)	<.001	.63 (.57 to .69)	<.001	.49 (.43 to .57)	<.001
No response	.66 (.65 to .67)	<.001	.80 (.79 to .81)	<.001	-32.2 (-35.2 to -29.2)	.02	.98 (.84 to 1.14)	.81	.64 (.49 to .81)	<.001

*The odds ratio represents the exponent of the estimated percentage of physicians receiving one or more payments or holding ownership interests compared with the reference group. CI = confidence interval; IRR = incidence rate ratio; OR = odds ratio.

†Generalized multivariable logistic regression model, two-sided P value.

‡The exponent of the B coefficient can be interpreted as the incidence rate ratio or the ratio of the logs of the annual mean number of payments received by a physician in each specialty classification compared with the reference group.

§Generalized multivariable negative binomial regression model, two-sided P value.

||The B coefficient of the dependent variable can be interpreted as the percentage difference in the mean annual per-physician value of general payments from the reference group for any variable.

¶Generalized multivariable linear model with gamma distribution and log-link, two-sided P value.

ownership interest compared with nononcologists. These relationships may represent the most impactful conflicts of interest (36). In particular, ownership/investment interest payments made up 17% of the total value of general payments for medical oncologists, demonstrating the need to further evaluate the impact of ownership interest in medical oncology.

The impact of financial relationships on physician behavior and patient perception in oncology remains controversial. An analysis of consensus statements on oncology drugs suggested that drug endorsement was more common when authors had financial conflicts of interest with the drug's manufacturer (41). A study of oncology abstracts showed that the majority of studies on economic analyses with financial disclosures supported the sponsor's product (42). However, another study of published cancer clinical trials found that interpretation of results was not influenced by authors' financial relationships (43). A survey of clinical trial participants suggests most cancer patients are not concerned about researchers' financial ties with industry, although a substantial minority advocate for transparency and disclosure (44). Ultimately, the common interest of oncologists, patients, and industry is to provide new and effective therapies (1,32,36).

Our analysis also revealed patterns of industry payments associated with physician and practice characteristics. Male sex was associated with a greater likelihood and value of industry payments. This is consistent with third-party data (non-OP) showing that female physicians received lower industry payments for education, speaker fees, and research than their male counterparts (45). Additionally, the large effect of sex on receipt of royalty/license payments is not surprising given that women are underrepresented in product design and development and this likely extends to physician involvement in the pharmaceutical and device industries (46–48). High spending areas were associated with a greater likelihood and number of payments, similar to other analyses of physician survey data (27). This may be explained by targeted marketing to physicians in areas with higher health expenditures. Sole proprietors were less likely to receive industry payments and had lower annual payments than physicians who were not. This may reflect changes in pharmaceutical marketing in recent years (49,50), where targeting group practices has a greater influence on sales.

Our study has potential limitations. CMS excluded certain records because of delay-in-publication requests, many of which were likely for research related to proprietary drugs or devices (50). Therefore, we focused on general payments and ownership interests. There may be inaccuracies inherent to the OP and NPPES databases. All demographic data linked to OP records is from NPPES, against which OP records are verified by CMS. While a minority of physicians do not have NPIs, our matching procedure successfully linked over 95% of physicians in OP to their NPI and NPPES demographic data. The retrospective nature of this study results in potential confounding, and there are other physician demographics (ie, age and practice type) that we could not control for because of limitations of available NPPES data. Despite potential under-reporting to Open Payments, which CMS is addressing through its ongoing compliance strategy (51), Open Payments data represent the most comprehensive nationwide data to date on physician payments and ownership interests.

As transparency of physician payments increases, it is important to understand the complexity of these relationships in oncology and to help guide interpretation by patients and stakeholders. Although some relationships may represent problematic financial interests, many have positive consequences for cancer care. Future policies should work toward managing

these relationships appropriately and fostering fruitful collaborations with industry.

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