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Industry Payments and Academic Influence in Reconstructive Microsurgery

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Abstract

Background Financial relationships between industry and microsurgeons help facilitate innovation but have the potential to bias a surgeon's academic work. To better understand industry–academic relationships, this study investigated the association between industry payments made to microsurgeons and their academic influence.

Methods A cross-sectional analysis of microsurgeons at Accreditation Council for Graduate Medical Education–accredited plastic surgery residency programs during the 2020–2021 academic year was performed. The Center for Medicare and Medicaid Services' Open Payments Database was used to collect industry payments (research and nonresearch related) to each surgeon. Academic influence was measured by Hirsch index (h-index) and number of publications. Mann–Whitney's *U* and Kruskal–Wallis' tests were used for statistical analysis.

Results Of the 199 microsurgeons identified, 156 (78.39%) received an industry nonresearch payment, but 0 (0.0%) received an industry research payment. Surgeons who received any amount of industry payments did not have a higher mean h-index or higher mean number of publications than surgeons with no industry payments. However, surgeons with total industry payments more than $10,000 ($n = 15$) had a higher number of publications than surgeons with no industry payments (135.47 vs. 36.02, $p = 0.0074$), $1 to $1,000 in payments (135.47 vs. 34.37, $p = 0.0006$), and $1,000 to $10,000 in payments (135.47 vs. 45.43, $p = 0.0268$). Surgeons with total industry payments more than $10,000 also had higher h-indices than surgeons with $1 to $1,000 in payments (24.4 vs. 10.34, $p = 0.0039$) and $1,000 to $10,000 in payments (24.4 vs. 11.34, $p = 0.0413$).

Keywords
- industry funding
- microsurgery
- surgical innovation
- academic surgeon
- plastic surgery

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Conclusion Industry funding is associated with higher h-index and higher number of publications for high earners (> $10,000). Private companies may favor these surgeons for their academic expertise.

Private companies have driven many technological advancements in the field of reconstructive microsurgery,[1] from the acoustic Doppler sonography to state-of-the-art "spy" devices that are used to plan reconstructive procedures. To help facilitate such innovations, companies must establish cooperative relationships with academic surgeons, who advance the field through research, education, and leadership roles. These relationships often involve payments not only for research but also for consulting, royalties, travel and lodging, education, and other related services.

In recent years, industry–academic relationships have come under scrutiny. While monetary support from industry helps facilitate advancements in patient care, evidence suggests that financial ties can bias a physician's academic work.[2–5] As an example, investigators with a financial conflict of interest (COI) are more likely than those without a COI to publish a positive conclusion in *Plastic and Reconstructive Surgery* (PRS) journals.[6]

Enacted in 2010, the Physician Payments Sunshine Act made industry payments to physicians in the U.S. public, which enabled the study of industry–academic relationships.[7–9] Ruan et al demonstrated that 78% of academic PRS surgeons received some type of industry payment in 2017.[10] In addition, receiving more than $2,000 was associated with a higher Hirsch index (h-index) for individual surgeons, suggesting that industry ties and research influence may occur in tandem.[10]

Although the relationship between industry funding and academic influence has been documented in PRS, data at the subspecialty level are limited. To our knowledge, this is the first study to comprehensively analyze the specific relationship between industry payments and academic influence in reconstructive microsurgery. We secondarily aimed to determine the relationship between National Institutes of Health (NIH) funding and academic influence for comparison.

Methods

Physician Selection

Faculty with fellowship training in microsurgery were identified using Websites for Accreditation Council for Graduate Medical Education (ACGME)-accredited plastic surgery residency programs during the 2020–2021 academic year. Inclusion criteria included plastic surgeons with any fellowship training in reconstructive microsurgery. Academic title (assistant professor, associate professor, or full professor), residency program director status, and microsurgery fellowship program director status were obtained for each physician.

Estimating Academic Influence

Academic success was measured via each surgeon's h-index and their total number of publications in 2019. The h-index captures both the number of publications and the number of citations associated with a surgeon. It thus serves as a validated measure of both academic productivity and quality.[11]

Funding Estimates

NIH funding was obtained from the NIH RePORTER Website (reporter.nih.gov) for each surgeon for the year 2019. Industry payment amounts were determined from the Centers for Medicare & Medicaid Services Open Payments Database (openpaymentsdata.cms.gov) for the year 2019. Payments were divided into two categories: research payments and general ("nonresearch") payments. Research payments were defined as those "in connection with a research agreement or research protocol." Nonresearch payments, defined as those with no "connection to a research agreement or research protocol," included charity, compensation, consulting fees, education, entertainment, food and beverages, gifts, grants, honoraria, royalties, and travel.[12] For each reconstructive microsurgeon identified, NIH funding, research payments, and nonresearch payments were recorded. Nonresearch payments were further divided into funding strata ($0, $1–$1,000, $1,000–$10,000, and > $10,000).

Statistical Analysis

Due to the nonnormality of the data, Mann–Whitney's *U* testing was used to compare average h-indices and the number of publications based on the receipt of any industry payments and NIH funding. To analyze the association between payment strata, h-index, and total number of publications, a Kruskal–Wallis's rank test was used. Kruskal–Wallis' rank tests were used due to the nonparametric nature of the data. Kruskal–Wallis' rank testing was also used to determine associations between average total nonresearch payment and total NIH funding with professor rank. Associations between average total nonresearch payment and total NIH funding with residency program director status and microsurgery fellowship program director status were determined using Mann–Whitney's U testing. In addition, Spearman's correlations were used to calculate correlations between average total industry nonresearch payments per physician, h-index, and number of publications.

Statistical analysis was performed using SAS 9.4 (SAS Institute Inc., Cary, NC.). All tests were two-sided with significance defined as *p*-value less than 0.05. This study was Institutional Review Board exempt as all data used is publicly available.

Table 1 Demographics of academic microsurgeons and industry payments

	Number	%
Number of academic programs	98	100
Number of academic surgeons	199	100
Industry payments	156	78.39
Nonresearch payments	156	78.39
Research payments	0	0.00
No payments	43	21.61%
NIH funding	20	10.05%
Mean h-index (SD)	11.56 (10.30)	
Mean number of publications (SD)	43.86 (73.2)	

Abbreviations: h-index, Hirsch index; NIH, National Institutes of Health; SD, standard deviation.

Results

Academic Reconstructive Microsurgeon Payment Landscape

A total of 199 plastic surgeons with fellowship training were identified across 98 ACGME-accredited plastic surgery residency programs (►**Table 1**). Of the 199 surgeons, 10.05% received NIH funding, and 78.39% received an industry payment in 2019. Industry payments were exclusively limited to nonresearch payments, with 100% of industry-funded microsurgeons receiving a nonresearch payment and 0% receiving a research payment; 21.61% of surgeons received no industry payment at all. Overall, reconstructive microsurgeons had a mean h-index of 11.56 (standard deviation [SD] 10.30) and a mean number of publications of 48.86 (SD 73.2).

Relationship of NIH and Industry Payments to Academic Influence

NIH funding ranged from $43,000 to $13,851,643, with a median payment of $794.608 (SD 4,071,976.08) (►**Table 2**). Receiving NIH funding was significantly associated with higher h-index ($p = 0.0018$) and higher number of publications ($p = 0.0043$) (►**Table 3**).

Nonresearch industry payments ranged from $7.50 to $544,791, with median payment amount of $366.99 (SD 52,283.30) (►**Table 2**). Receiving a nonresearch payment was not significantly associated with a higher mean h-index ($p = 0.6087$) or higher mean number of publications ($p = 0.9769$) (►**Table 3**). Additionally, there was a nonsignificant correlation between total industry payments and h-index ($p = 0.0927$) and number of publications ($p = 0.1043$) (►**Table 4**).

Nonresearch industry payments were further stratified by payment category. Forty-three surgeons received $0 in nonresearch industry payments, 111 surgeons received $1 to $1,000 in payments, 30 surgeons received between $1,000 and $10,000 in payments, and 15 surgeons received more than $10,000 in payments in 2019 (►**Table 5**). Surgeons with more than $10,000 in payments were found to have significantly higher mean h-indices than surgeons with $1 to $1,000 in payments ($p = 0.0039$) and surgeons with $1,000 to $10,000 in payments ($p = 0.0413$). Surgeons with more than $10,000 in payments were also found to have significantly higher number of publications than surgeons with no industry payments ($p = 0.0074$), $1 to $1,000 in payments ($p = 0.0006$), and $1,000 to $10,000 in payments ($p = 0.0268$) (►**Table 6**).

Types of nonresearch industry payments differed greatly among payment categories. For the 111 physicians receiving $1 to $1,000 in nonresearch industry payments, 97.6% of payments were for food and beverages (►**Table 7**). For the 43 patients receiving $1,000 to $10,000 in payments, a majority of payments (86.4%) were also for food and beverages. In contrast, for the 15 physicians receiving more than $10,000 in industry payments, only 55.59% of payments were for food and beverages.

Differences also existed in payment amounts per categories; 92.33% of the overall $31,147.89 payments given to surgeons in the $1 to $1,000 payment category went to food and beverages (►**Table 8**). For surgeons receiving $1,000 to $10,000 in payments, almost an equal amount of total nonresearch payments was given for consulting (29.09%) as food and beverages (29.29%). For surgeons with more than

Table 2 Payments to microsurgeons

	Total industry (nonresearch)	Total industry (research)	NIH
Number with payment	156	0	20
Number without payment	43	199	179
Payments ($)			
Median	$366.99	–	$794,608.00
SD	52,283.30	–	4,071,976.078
Minimum	$7.50	–	$43,000.00
Maximum	$544,791.00	–	$13,851,643.00
Sum	$1,650,377.00	–	$49,349,587.00

Abbreviations: NIH, National Institutes of Health; SD, standard deviation.

Table 3 Relationship of average h-index and number of publications with payment type

	Average h-index				Average number of publications		
	Did not receive payment	Received payment	*p*-Value	Did not receive payment		Received payment	*p*-Value
Industry nonresearch payment	11.53	11.57	0.6087	36.02	46.06	0.9769	
NIH funding	10.55	20.45	**0.0018**	35.91	113.75	**0.0043**	

Abbreviations: h-index, Hirsch index; NIH, National Institutes of Health.
Note: Bold values indicate statistical significance.

Table 4 Correlation coefficients of academic influence with industry payments

	Correlation coefficients	
	h-index	Number of publications
Total industry nonresearch payments	0.0927	0.1043

Abbreviation: h-index, Hirsch index.

Table 5 Demographics by nonresearch payment category

	N	Mean h-index	Mean number of publications
$0	43	11.53	36.02
$1–$1,000	111	10.34	34.37
$1,000–$10,000	30	11.23	43.43
> $10,000	15	21.07	135.47

Abbreviation: h-index, Hirsch index.

Table 6 Relationship of h-index and number of publications with payment category

	p-Value (h-index)	*p*-Value (publications)
$0 vs. $1–$1,000	0.6738	0.8619
$0 vs. $1,000–$10,000	0.9923	0.9963
$0 vs. > $10,000	0.0995	**0.0074**
$1–$1,000 vs. $1,000–$10,000	0.9186	0.832
$1–$1,000 vs. > $10,000	**0.0039**	**0.0006**
$1,000–$10,000 vs. > $10,000	**0.0413**	**0.0268**

Abbreviation: h-index, Hirsch index.
Note: Bold values indicate statistical significance.

Table 7 Types of nonresearch payments

	$1–$1,000 ($n = 111$ physicians)	$1,000–$10,000 ($n = 43$ physicians)	> $10,000 ($n = 15$ physicians)
Number of nonresearch payments	542	478	644
Charity	0 (0%)	1 (0.21%)	0 (0%)
Compensation	0 (0%)	7 (1.46%)	55 (8.54%)
Consulting	2 (0.37%)	11 (2.3%)	58 (9.01%)
Education	0 (0%)	3 (0.63%)	1 (0.16%)
Entertainment	0 (0%)		0 (0%)
Food and beverages	529 (97.6%)	413 (86.4%)	358 (55.59%)
Gift	0 (0%)	1 (0.21%)	0 (0%)
Grant	0 (0%)	1 (0.21%)	0 (0%)
Honoraria	1 (0.18%)	0 (0%)	0 (0%)
Royalties	0 (0%)	0 (0%)	5 (0.78%)
Travel	10 (1.85%)	40 (8.36%)	167 (25.93%)

Table 8 Amount of nonresearch payments by type

	$1–$1,000 ($n = 111$ physicians)	$1,000–$10,000 ($n = 43$ physicians)	> $10,000 ($n = 15$ physicians)
Total nonresearch payment	$31,147.89	$88,470.39	$1,530,758.42
Charity	$0	$1,184 (1.34%)	0 (0%)
Compensation	$0	$10,000 (11.30%)	217,015 (14.18%)
Consulting	557.37 (1.79%)	25,737 (29.09%)	464,785.75 (30.36%)
Education	$0	3,258.73 (3.68%)	68.41 (0.0045%)
Entertainment	$0	100.47 (0.11%)	0 (0%)
Food and beverages	28,757.84 (92.33%)	25,910.51 (29.29%)	24,594.66 (1.61%)
Gift	$0	2,054 (2.32%)	0 (0%)
Grant	$0	7,500 (8.48%)	0 (0%)
Honoraria	400 (1.28%)	0 (0%)	0 (0%)
Royalties	$0	0 (0%)	744,578.49 (48.64%)
Travel	1,432.68 (4.60%)	12,725.68 (14.38%)	79,716.11 (5.21%)

$10,000 in industry payments, a majority of total payments went to royalties (48.64%), followed by consulting (30.036%). Food and beverage payments were only 1.61% of total overall payments.

Relationship of NIH and Industry Payments to Academic Rank and Positions

NIH funding was significantly associated with higher academic rank. Larger amount of NIH funding was associated with full professorship ($1,177,698.60) than with assistant professorship ($26,689.88) ($p = 0.0122$) (►**Table 9**). There was no significant association between industry payments and academic titles. Notably, there was also no significant relationship between amount of NIH funding and residency program director status ($p = 0.9409$) or between total industry payments and residency program director status ($p = 0.2511$) (►**Table 10**). Similarly, there was no significant relationship between total NIH funding and microsurgery fellowship program director status ($p = 0.9968$) and no significant relationship between total industry payment and microsurgery fellowship program director status ($p = 0.6582$) (►**Table 11**).

Discussion

Industry–academic relationships help foster technological innovations in plastic surgery. However, they are scrutinized for their potential to bias a surgeon's academic work. This study aimed toward understanding the potential for industry bias in academic reconstructive microsurgery, one of plastic surgery's most innovative subspecialties. To our knowledge, this is the first comprehensive analysis of the association between industry payments and academic influence of

Table 9 Relationship of academic title with total payment

	Academic title			
	Assistant professor	Associate professor	Full professor	*p*-Value
Industry nonresearch payment (total)	$2,494.90	$15,888.60	$18,610.07	0.1434
NIH funding (total)	$26,689.88	$118,966	$1,177,698.60	**0.0122**

Abbreviation: NIH, National Institutes of Health.
Note: Bold value indicates statistical significance.

Table 10 Relationship of residency program director status with total payment

	Residency program director status		
	Program director	Not program director	*p*-Value
Industry nonresearch payment (total)	$894.41	$8,726.27	0.2511
NIH funding (total)	$32,336.09	$261,999.41	0.9409

Abbreviation: NIH, National Institutes of Health.

Table 11 Relationship of microsurgery fellowship program director status with total payment

	Microsurgery fellowship program director status		
	Program director	Not program director	*p*-Value
Industry nonresearch payment (total)	$287.19	$9,029.01	0.6582
NIH funding (total)	$611,123.69	$266,294.38	0.9968

Abbreviation: NIH, National Institutes of Health.

recipient microsurgeons. This cross-sectional study shows that industry payments for research are rare in academic microsurgery, but nonresearch payments are prevalent. A selected group of highly paid surgeons earning more than $10,000 receive most of their payments in the form of royalty payments. The association between nonresearch payments and academic influence is limited to this group of surgeons, who have significantly greater academic reach as measured by h-index and number of publications.

Although the present study was cross-sectional, its findings in the context of prior literature suggest that the prevalence of industry–academic relationships may be increasing over time. In a prior cross-sectional analysis, the field of plastic surgery had one of the lowest percentages of funded surgeons, with around 50% of plastic surgeons receiving industry payments in 2014, behind otolaryngology (57.9%), orthopaedic surgery (62.4%), urology (63.1%), and neurosurgery (87.8%).[13] Our study demonstrates that just 5 years later, in 2019, the prevalence of industry funding to reconstructive microsurgeons approaches 80%. It is plausible that reconstructive microsurgeons are more likely to receive industry payments than their counterpart subspecialists, among which no distinction was made in the 2014 cross-sectional analysis. However, a more likely explanation for the perceived disparity is that industry–academic relationships are simply becoming more common as the private sector becomes more involved in surgical innovation.

An important distinction made in the present study was that between research and nonresearch payments. The 80% of academic microsurgeons who received industry payments all received nonresearch payments, with no surgeons (0%) receiving industry payments for research endeavors, such as randomized-controlled trials employing new products. The greater prevalence of nonresearch payments in reconstructive microsurgery is seen in other surgical subspecialties too.[14,15] Chen et al showed that 89% of payments made to orthopaedic surgeons were nonresearch payments. However, the fact that not even a few reconstructive microsurgeons received a research-related payment stands out. It suggests one of two things: either the private sector is not interested in supporting the scientific endeavors of reconstructive microsurgeons or the private sector does not want to do so with open sponsorships, instead choosing to "fund" partnering surgeons with consulting, travel, and other nonresearch payments. Neither interpretation is positive for the current state of industry–academic relationships in reconstructive microsurgery, but both are worth consideration.

Another central finding is that surgeons paid more than $10,000 had greater academic success than those paid less. To put this into perspective, the median payment amount to microsurgeons in our study was $366.69, which is within the range of median payments to plastic surgeons in the literature, $324.49 to $6,244.[13,15–17] Only 7.5% of microsurgeons in this study constituted the category receiving more than $10,000, making this a highly selected group, and their mean h-index surpassed the others by nearly 10 points. This may suggest that private companies target those who have distinguished themselves through impactful research for their knowledge, reputation, and expertise—which may come as no surprise. This finding aligns with the literature showing that higher paid surgeons have greater academic influence than lesser paid surgeons.[16,18] It is further supported by recent work demonstrating that American Society for Reproductive Medicine conference speakers received higher general payments than the average plastic surgeon.[19] Ruan et al recently demonstrated a payment threshold of $2,000 for funding to be significantly associated with h-indices for all academic plastic surgeons, including microsurgery, craniofacial, hand, esthetic, and burn surgery.[10] Our research suggests that a $10,000 threshold may carry the same association when focused exclusively on microsurgeons to date.

We also found that the types of payments made to the surgeons in the more than $10,000 funding cohort were significantly different. While most of the payments to those making less than $10,000 were for food and beverages, which is consistent with the literature,[13,16,20,21] most of the payments to those making more than $10,000 were for royalties. This finding suggests that the highest paid microsurgeons are inventors who have patented products. Companies license medical patents for the purpose of producing, selling, and distributing the inventor's product on the market. When these products are sold, the surgeon–inventors are compensated in the form of royalties, creating a financial tie between the surgeon and the company. The prevalence of royalties and this study's finding that research-related payments are lacking may suggest that companies favor allocating their resources to the later stages of innovation—production, sales, and distribution on the market—over the earlier stages of product ideation and testing. Moreover, it suggests that not all payment types are equivalent, and that royalty payments may be the specific cause of industry bias in reconstructive microsurgery.

It is worth noting that senior attendings at academic programs in the United States did not receive higher payment amounts. To be specific, professorship status, residency program director status, and microsurgery fellowship program director status were not associated with total payment amounts. This finding suggests that these leaders, who serve as role models for residents and fellows, may not be prone to industry bias when making decisions that their trainees may emulate, like which devices to use in the operating room. However, research on the association between seniority and industry payments is variable. Some studies suggest that level of experience of plastic surgeons has an inverse relationship with payment amounts. Others have shown a significant association between the payment amount and academic rank, leadership position, and career length.[21–23] Future research is needed to characterize the influence of industry on those in leadership positions, as industry bias among these surgeons may not only affect their own clinical decision-making and reporting of outcomes but also that of the next generation of microsurgeons.

Finally, as a control, we found that NIH-funded microsurgeons were more likely to have higher h-indices and number of publications. This is consistent with industry payment explorations in plastic surgery that show that NIH funding is associated with higher h-index, h5-index, career publications, and citations, while industry payments were not.[23]

There are several limitations of this study to consider. This study is limited by the data available in the Open Payments Database and the information accrued by the Center for Medicaid and Medicare Services. Some literature has shown minor inaccuracies in the data reporting, specifically in the listing of specialties, which may have led to the exclusion of microsurgeons from the overall analysis.[24,25] Inaccuracies may have also resulted from the use of faculty Websites which may have had outdated or incorrect data regarding our study population. Other metrics regarding the faculty studied, such as age, sex, race, institution caliber, geographic location, etc., were also not included in this analysis, which have been previously shown to have significant influences in amount of funding.[22,26,27] Moreover, h-indices and number of publications are only a surrogate marker of academic influence. While shown previously to be a validated marker of academic output in academic reconstructive microsurgery, h-indices do not account for self-citation or authorship order.[28] Examining the number of publications aimed to help serve as an additional marker and corroborate findings of the h-index. In addition, this study aimed to better characterize the relationship and role industry funding may play in microsurgery and does not serve as a commentary as to the appropriateness or ethics behind this relationship.

Conclusion

Although industry payments for research are rare in academic microsurgery, nonresearch payments are prevalent, and their association with greater academic influence may be limited to a selected cohort of high-earning surgeons with greater than $10,000 in yearly payments. Royalties constitute most of the money disbursed to this cohort, which may suggest that industry is most influential during the latter stages of microsurgical innovation, including production, sales, and distribution of products. Further research is needed to determine the potential implications of this relationship on industry bias in the field.

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Conflict of Interest
None declared.

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