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Does industry funding mean more publications for subspecialty academic plastic surgeons?

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ABSTRACT

Background: Conflict of interest among physicians in the context of private industry funding led to the introduction of the Physician Payments Sunshine Act in 2010. This study examined whether private industry funding correlated with scholarly productivity in the respective subspecialties of plastic surgery and the wider academic plastic surgery community.

Materials and methods: Full-time plastic surgeons and their academic attributes were identified via institutional websites. Fellowship-trained individuals were segregated into subspecialties of microsurgery, craniofacial surgery, hand surgery, esthetic surgery, and burn surgery. The Center for Medicare and Medicaid Services Open Payment database was used to extract industry funding information. Each individual's bibliometric data were then collected through Scopus to determine the correlation between selected surgeon characteristics, academic productivity, and industry funding.

Results: Nine hundred and thirty-five academic plastic surgeons were identified, with 532 having defined subspecialty training. Academic bibliometrics among subspecialty surgeons were comparable among the five groups with esthetic and craniofacial surgeons displaying a preponderance of attaining more industry funding ($P = 0.043$) and career publications respectively, with the latter not attaining statistical significance ($P = 0.12$). Overall, research-specific funding ($P = 0.014$) and higher funding amounts ($P < 0.0001$) correlated with higher Hirsch indices in tandem with higher academic rank. A funding level of $2000 appeared to be the approximate cutoff above which scholastic productivity became apparent.

Conclusions: Our study demonstrated in detail the association between industry funding and academic bibliometrics in academic plastic surgery of every subspecialty. Even at modest amounts, industry support, especially when research designated, positively influenced research and therefore, academic output.

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Introduction

A delicate relationship exists between the scientific community and its funding sources. Significant resources are required to engage in basic scientific research and its clinical translation.[1] Private industry is oftentimes the only candidate capable of making such investments. As a result, academic researchers bear the burden of accountability to multiple parties, each with its own agendas and goals.[2]

Academic researchers may experience clear conflicts of interest when working on privately funded projects, and this topic has gained attention in recent years.[3,4] The introduction of the Physician Payments Sunshine Act was an attempt to alleviate concerns by publically publishing all financial transactions between clinicians and industry. This forced disclosure elucidated the pervasiveness of these financial relationships. It was truly eye-opening, and journal editors took notice and responded by making financial disclosures a mandatory component of almost all published work.[5,6] As other countries have shown,[7] despite the potential for bias, many of the advancements in medicine would not have been possible without appropriate financial backing from industry.

The link between federal grant acquisition and scholarly output has been well established in a number of surgical disciplines.[8-11] To this end, the Hirsch index (h-index) has recently been popularized and adopted as a scholastic output measure in a variety of surgical specialties with fairly congruent results.[12-14] We seek to ascertain if private industry funding serves a similar purpose in plastic and reconstructive surgery and its subspecialties of microsurgery, craniofacial, hand, esthetic, and burn surgery, associating with scholarly productivity in academic clinicians.

Materials and methods

This study was exempt from Institutional Review Board approval due to all accessed information being public and involving no human subjects. The American Medical Association's Fellowship and Residency Electronic Interactive Database Access System[15] was accessed, and a list of plastic surgery residency training programs, both integrated (72) and independent (67), was acquired. Collectively, the two separate searches yielded a total of 97 unique institutions, and each of their websites was accessed for faculty listings. Only full-time academic faculty listed on the program websites were included in our study. Faculty member demographics included were as follow: age, gender, departmental appointment (chair/chief of division, faculty member), academic rank (instructor, assistant professor, associate professor, professor, endowed professor), Fellow of the American College of Surgeons membership, and fellowship subspecialty training (microsurgery, craniofacial surgery, hand surgery, esthetic surgery, and burn surgery).

For each plastic surgery faculty member, bibliometric data were extracted from Scopus (www.scopus.com)[16] as a measure of scholarly activity. This specifically included the h-index, h5-index, total publications, and total citations. The h-index serves as a useful measure for the academic scholar because the formula takes into account not only the total number of publications but also the impact of these publications. The impact of each publication is measured by the number of times an article is subsequently cited. The h-index helps to establish a balance between being prolific and highly relevant. As an extension of the h-index, the h5-index is the reflection of scholarly productivity over the most recent 5 years.

Our exploration of industry funding to individual faculty members was performed through the Center for Medicare and Medicaid Services Open Payment database (www.cms.gov).[17] This database (made accessible via the Physician Payment Sunshine Act) is updated annually, allowing free public access to information on funding and payments from industries to the medical community. Data on each faculty member's payments paralleled the funding categories shown on the database: general (payment unrelated to research including payments for consultation, education, and honoraria for formal speeches), research (payment associated with research work), associated research (payment associated with research work where clinician is principal investigator), and ownership (investment and ownership in companies). We also performed a summation of the four categories to derive what we termed "total industry payment." Since 2015 is the year with the most updated database, we chose this time point as the foundation of our study.

Statistical analysis

For statistical comparisons of continuous variables, paired *t*-test and analysis of variance were adopted as tools for calculation, whereas chi-squared test was used for the analysis of categorical data. P-value <0.05 was defined as statistically significant. We performed a specific calculation using the aforementioned methods in determining the funding threshold, above which academic bibliometrics exponentially increase. This was conducted via chi-squared analyses of academic bibliometrics (h-index, h5-index, citations, and publications) between different funding amounts grouped in pairs reflected as above or below a predetermined value ranging from unfunded to $50,000. We started with the unfunded ($0) surgeons and made $500 increments each time, regrouping them and recalculating the difference in mean bibliometrics between the groups above and below the defined funding amount. All calculations were conducted using GraphPad Prism (GraphPad Software Inc, San Diego, CA).

Results

Through our preliminary data extraction, 935 academic plastic surgeons were identified via the search protocol, and demographics were displayed in Table 1. In 2015, 726 (77.6%) received industry funding as reported on the open access domain (Fig. 1). Five hundred and thirty-two of the total underwent clearly defined fellowship training with 120 in microsurgery, 140 in craniofacial surgery, 175 in hand surgery, 49 in esthetic surgery, and 20 in burn surgery (Table 2). Twenty-eight had more than one fellowship training registered.

Table 1 – Plastic surgery faculty demographics.

Demographics	n	(%)
Age (mean years, SD)	50.97, 11.36	
Gender		
Male	754	80.64
Female	181	19.36
Departmental chair/Chief of division		
Yes	164	17.54
No	771	82.46
FACS		
Member	409	43.74
Non-member	526	56.26
Academic rank		
Instructor	25	2.67
Assistant	397	42.46
Associate	193	20.64
Professor	165	17.65
Endowed professor	30	3.21
Undisclosed	125	13.37

FACS = Fellow of the American College of Surgeons.

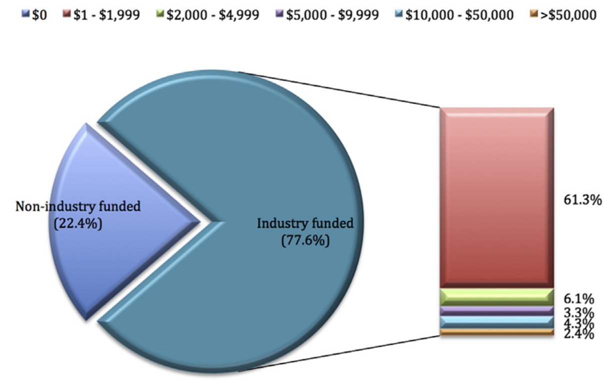

Fig. 1 – Proportion of academic plastic surgeon receiving various amounts of industry funding. (Color version of figure is available online.)

Overall, plastic surgeons who received funding in research attained significantly higher scholastic output in h-index (15.31; standard deviation [SD] 11.44) than their counterparts who received no funding (10.61; SD 12.01; $P = 0.014$) or just nonresearch contributions (9.77; SD 9.7; $P = 0.0002$) (Fig. 2). When organizing scholastic output bibliometrics with regard to total industry payments received, it was found that there was a significant increase in productivity as one advanced from a low-payment category to a high-payment category ($P < 0.0001$). H-indices of unfunded academic plastic surgeons (11.61; SD 12.09) compared with industry-funded individuals in the $10,000-$50,000 (17.67; SD 13.42) and >$50,000 (19.27; SD 11.19) categories were significantly different, as shown in Figure 3. On closer inspection, the threshold at which industry funding became significant in positively influencing academic productivity measured by h-index appeared to be around the amount of $2000 ($P = 0.037$).

As surgeons advanced up the academic ladder, there was an associated increase in the value of industry funding ($P = 0.012$) as demonstrated in Table 3. The h-index and h5-index were found to increase with rising academic rank ($P < 0.0001$) and total career publications ($P < 0.0001$). After controlling for academic rank, it was revealed that academic surgeons receiving industry funding in excess of $2000 had significantly higher h-indices than their colleagues who received funding under $2000. This was demonstrated at every rank level from assistant professors ($P < 0.0001$) to endowed professors ($P = 0.0003$) in Figure 4.

On subspecialty fellowship analysis of the 532 plastic surgery faculty members, microsurgery, craniofacial, hand, esthetic, and burn surgeons have comparable demographics overall (Table 2). Age was the only variable that showed a statistically significant variation between the groups ($P = 0.036$), with the highest mean attained by burn surgeons (51.8; SD 10.5) and the lowest by microsurgeons (47.7; SD 9.7). Gender distribution ($P = 0.52$), Fellow of the American College of Surgeons membership ($P = 0.67$) and academic ranks ($P = 0.27$) were largely similar. Twenty-eight surgeons had more than one defined fellowship training experience on record. When compared with faculty trained in a single subspecialty, there was no difference in the amount of general ($P = 0.98$) or total industry funding ($P = 0.71$) received, nor the h-index attained ($P = 0.3$).

The distribution of industry funding between the five subspecialties revealed no difference in the number of surgeons being funded between the groups ($P = 0.44$). However, there was a significant positive skew towards esthetic surgeons in the context of both mean general funding amount ($P = 0.035$) and designated research funding amount ($P = 0.015$), which attained dollar values of $10,551 (SD 39,356) and $1793 (SD 8964), respectively. Combining general and research-designated funding (total industry funding), the variation between the five specialties also attained significance ($P = 0.043$). Applying the identical funding threshold of $2000 as the general plastic surgeon population as defined previously, significant differences were demonstrated between the subspecialties in the proportion of surgeons attaining this threshold ($P = 0.027$). The highest percentage of surgeons achieving this funding threshold came from the esthetic (22.22%) and burn (26.67%) groups, whereas the lowest (8.57%) was attained by the craniofacial surgery group (Table 4).

Examining academic output between subspecialties, none of the bibliometrics of h-index ($P = 0.49$), h5-index ($P = 0.17$), citation counts ($P = 0.83$), or total publications ($P = 0.12$) revealed any difference between the groups. Craniofacial surgeons did demonstrate a greater preponderance of achieving more career publications (45.26; SD 78.68) than esthetic and burn surgeons (23.85; SD 29.86), but the number fell short of attaining significance. However, individuals receiving over $2000 in total industry funding in the microsurgery ($P = 0.003$) and hand surgery ($P = 0.011$) groups did achieve significantly higher h-indices (Fig. 5).

Table 2 – Subspecialty faculty demographics.

	Microsurgery		Craniofacial surgery		Hand surgery		Esthetic surgery		Burn surgery		P
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	
Total	120	23.81	140	27.78	175	34.72	49	9.21	20	3.76	
Age (mean, SD)	47.72, 9.7		48.46, 10.38		51.02, 10.15		47.67, 7.65		51.83, 10.46		0.036
Gender											0.52
Male	96	80	118	84.29	145	82.86	36	73.47	16	80	
Female	24	20	22	15.71	30	17.14	13	26.53	4	20	
Departmental chair/Chief of division											0.2
Yes	17	14.17	30	21.43	32	18.29	4	8.16	3	15	
No	103	85.83	110	78.57	141	81.71	45	91.84	17	85	
FACS											0.67
Member	53	44.17	64	45.71	73	41.71	17	34.69	10	50	
Non-member	67	55.83	76	54.29	102	58.29	32	65.31	10	50	
Rank											0.27
Instructor	2	1.67	2	1.43	5	2.86	1	2.04	0	0	
Assistant	65	54.17	66	47.14	74	42.29	26	53.06	8	40	
Associate	22	18.33	36	25.71	38	21.71	8	16.33	2	10	
Professor	16	13.33	27	19.29	29	16.57	6	12.25	6	30	
Endowed professor	3	2.5	3	2.14	9	5.14	1	2.04	0	0	
Undisclosed	12	10	6	4.29	20	11.43	7	14.29	4	20	

FACS = Fellow of the American College of Surgeons.

Discussion

Our study represented the first comprehensive review of subspecialty-specific industry funding pattern and scholastic output association in the field of plastic and reconstructive surgery. Bibliometrics among fellowship-trained surgeons were comparable among the five groups, with esthetic and burn surgeons displaying a preponderance of attaining more industry-associated funding. Overall, research-specific funding and higher funding amounts correlated with higher h-indices in tandem with higher academic rank. A funding level of $2000 appeared to be the approximate cutoff, above which scholastic productivity became apparent.

The financial relationship between private industry and the medical community is longstanding and widely prevalent throughout all clinical specialties. A cross-sectional national study conducted in 2007 established a >90% rate of clinician collaboration with the pharmaceutical industry in the 3167 clinicians surveyed.[18] Plastic surgeons are no exception because there is a drive to be innovative and be at the forefront of using novel products designed to heal, augment, stabilize, bridge, and implant. Inevitably, this involves

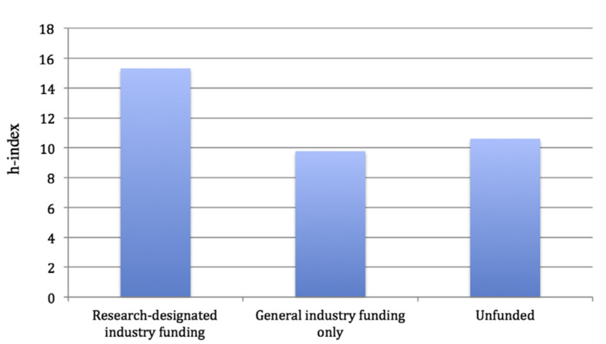

Fig. 2 – Comparison of scholastic productivity (h-index) between individuals with industry research funding, industry general funding only, and no industry funding. (Color version of figure is available online.)

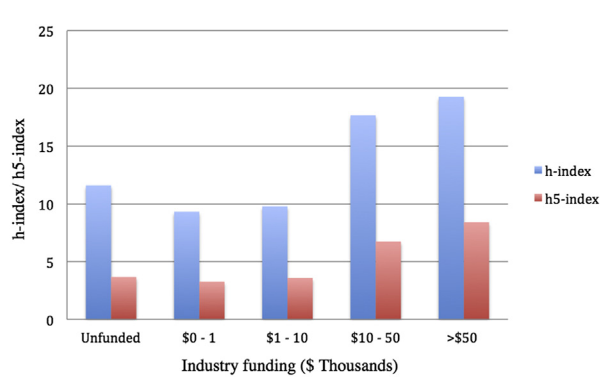

Fig. 3 – Scholastic productivity measured using h-index and h5-index at varying levels of industry funding. (Color version of figure is available online.)

Table 3 – Association of academic rank with numerical values of industry funding and scholastic productivity bibliometrics.

Rank	Industry funding (mean, SD)	h-index (mean, SD)	h5-index (mean, SD)	Career publications (mean, SD)
Instructor	$1016, 2678	5.74, 5.38	1.47, 1.39	14.32, 19.14
Assistant	$2378, 15,317	5.52, 5.9	3.12, 6.3	15.17, 22.91
Associate	$8531, 40,343	11.52, 8.24	4.87, 6.43	39.91, 41.36
Professor	$10,003, 47,394	18.81, 11.3	4.4, 4.04	77.47, 73.8
Endowed professor	$13,295, 47,413	30.89, 17.32	9.86, 8.06	185.7, 178.3
P	0.012	<0.0001	0.0012	<0.0001

significant industry input, and oftentimes funding,[2] which we demonstrated across different plastic and reconstructive surgery subspecialties. Critics of this relationship highlight industry influence in altering physicians' prescribing patterns[19] either consciously or subconsciously as well as the erosion of academic integrity through misrepresentations in publications.[20]

The risk-benefit analysis of whether the financial advantages of reliable industry support outweigh the detriments of industry infiltration into academia falls beyond the scope of our article. We do not seek to comment or place a value judgment on the validity of research projects derived through industry-funded grants. However, we did seek to establish on a more fundamental level, if industry funding is linked to academic vibrancy and productivity in a manner similar to other public grant awards in the field of plastic and reconstructive surgery.[9-11] Since temporal relationships cannot be determined in a cross-sectional study, we delineated a relationship of association instead of causation between industry funding and academic output.

Academic plastic surgeons who received funding for research purposes achieved much higher h-indices than their colleagues who received either no funding or nonresearch funding. This is unsurprising because general funding such as sponsored dinners, consultation, instructional courses, and invited lecture honoraria do not meaningfully impact a clinician's scholastic output. On the subspecialty level, this was demonstrated in the esthetic surgery group, which was not seen to achieve higher academic bibliometrics, despite having attained significantly higher general industry funding. This positive association between industry research funding and scholastic output mirrored the high scholastic output achieved following National Institutes of Health (NIH) funding in plastic surgery[8] and other clinical disciplines[21-23] and was recently similarly demonstrated by Ahmed *et al.*[24] Quite simply, research dollars enable highly productive principal investigators to quickly and easily translate funding into quantifiable research outcomes and clinical improvements. Of note, a selection bias exists because the most talented researchers are better able to compete and attain highly competitive NIH grants.

Aside from having similar industry funding patterns, the subspecialty academic surgeons in microsurgery, craniofacial surgery, hand surgery, esthetic surgery, and burn surgery share fairly uniform characteristics in terms of demographics, surgeon funding frequency, and bibliometric scores. Esthetic surgeons consistently receive higher industry funding amounts than the other subspecialties. This could likely be due to more frequent exposure to new commercial products used in esthetic surgical care and the inadvertently increased interaction with the private sector that subsequently led to more funding opportunities. This injection of private industry finances appeared to be of both research and nonresearch designation. It is worthy to note that this attainment of significantly higher funding amounts, including research-designated funding, did not translate into a measurable increase in academic productivity in esthetic surgeons in accordance with our observations in the wider plastic and reconstructive surgery population. On the contrary, craniofacial surgeons whom achieved the least total industry funding were found to attain the highest number of publications among all subspecialty surgeons, despite failing to attain significance in this measure. This perfectly demonstrated the influence of contributors to academic output which were beyond the scope of this study to capture, such as funding from the Department of Defense, the NIH, as well as various society and association awards including the Plastic Surgery Foundation awards and American Association of Plastic Surgeons scholarships.

The association of higher academic rank with greater scholastic productivity has been well explored in plastic surgery and other specialties.[14,25,26] Seniority is a firmly established predictor of the h-index,[14] and as shown in Table 3, industry funding amounts increase with rank. There are many

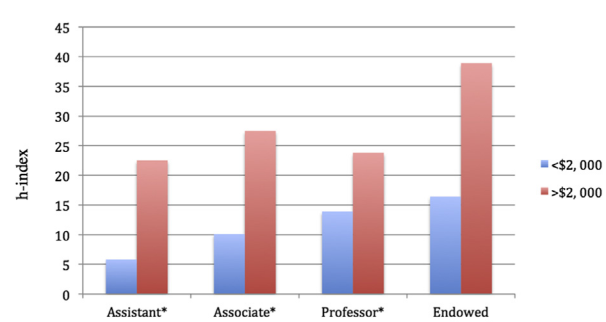

Fig. 4 – Comparison of scholastic productivity of plastic surgeons of varying academic ranks receiving total industry funding <$2000 and >$2000. *Statistically significant (*P* < 0.05). (Color version of figure is available online.)

Table 4 – Subspecialty industry funding and bibliometrics comparisons.

	Microsurgery		Craniofacial surgery		Hand surgery		Esthetic surgery		Burn surgery		P
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	
Industry funding status											0.44
Funded	100	83.33	106	75.71	143	81.71	40	81.63	14	70	
Unfunded	20	16.67	34	24.29	34	18.29	9	18.36	6	30	
General funding (mean, SD)	$3702, 14,426		$530.1, 1061		$3858, 20,669		$10,551, 39,356		$2274, 5947		0.035
Research-designated funding (mean, SD)	$159.6, 1539		$1.422, 16.82		$127.5, 1590		$1793, 8964		$0, 0		0.015
Total industry funding (mean, SD)	$7938, 30,785		$825.2, 3692		$4684, 23,590		$11,536, 40,145		$2160, 5810		0.043
Total industry funding amount											0.027
<$2000	94	78.33	128	91.43	145	82.86	38	77.55	15	75	
>$2000	26	21.67	12	8.57	30	17.14	11	22.45	5	25	
h-index (mean, SD)	9.49, 8.55		10.45, 10.12		10.14, 10.49		8.10, 7.58		7.75, 8.39		0.49
h5-index (mean, SD)	3.77, 3.89		3.95, 4.19		3.28, 3.71		2.90, 4.08		2.20, 2.07		0.17
Citations (mean, SD)	769.4, 1665		845.8, 2667		820.9, 2138		468.6, 858.4		578.2, 1028		0.37
Career publications (mean, SD)	30.33, 38.61		45.26, 78.68		39.09, 62.46		24.78, 35.83		23.85, 29.86		0.12

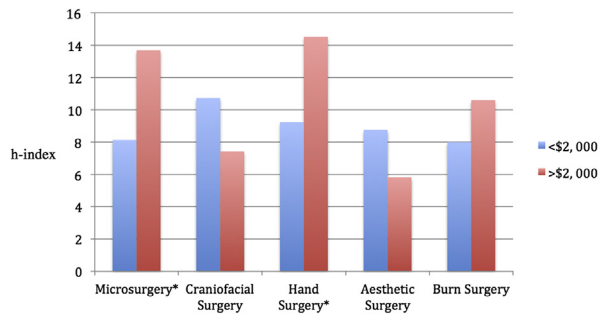

Fig. 5 – Comparison of scholastic productivity of subspecialty plastic surgeons receiving total industry funding <$2000 and >$2000. *Statistically significant ($P < 0.05$). (Color version of figure is available online.)

reasons for this association. Since more senior surgeons typically have better reputations and more-established careers within the specialty, they have a superior ability to obtain funding. In addition, more senior academic surgeons are likely to have larger research teams that are able to secure more avenues of funding. The comparable distribution among the subspecialties of academic surgeons of various ranks could certainly be one of the reasons we failed to demonstrate significant differences in bibliometrics between the groups because their collective powers of influence on the indices would work out to be similar.

The potency of industry funding became more apparent when potential confounders were taken into account. Greater scholastic impact was correlated with higher funding amounts when academic rank and subspecialties were controlled for. This was clearly exemplified in academic surgeons in microsurgery and hand surgery where an increase in private funding above $2000 triggered a marked increase in calculated h-index beyond what was expected in the general plastic surgery population. This tied in with our conjecture that a critical threshold value of industry funding existed over which the scholastic output measures would start to increase significantly. Below this value, their productivity matched those of unfunded peers. What we found remarkable, was how modest this amount was compared with the monumental costs of clinical trials, database maintenance, or research support staff employment. To put this figure in context, an even lower threshold of $1000 was reported in academic Otolaryngologists.[11] Therefore, achieving notable scholarly impact does not always equate to the need for massive fund injections. Modest funding contributions would be sufficient to promote increased academic exposure through conferences and scientific interactions.[11] This, in turn, promotes opportunities for collaboration and the generation of new ideas, which can lead to more academic throughput and productivity.

Alternatively, a plastic surgeon already having high visibility or influence may be directly sought after by industry to evaluate new products and techniques. These interactions further consolidate relationships between individuals and industries and inadvertently lead to more funding opportunities. This very realistic reversal in causality retains the association of high industry funding in academics with high research productivity, making it impossible to ascertain the inciting event in a cross-sectional study. However, despite the challenges in establishing cause and effect without a temporal model, our study strongly hinted at industry funding being a driver of academic productivity. This observation came from the implicit understanding that the recognition of research prominence is inextricably tied to academic seniority, for which academic rank best reflects. When academic rank was controlled for, industry funding continued to positively associate with academic output at every level, despite the expectation that only the most senior academic surgeons would be targeted for industry funding in the alternative interpretation of causality. Junior faculty had, therefore, likely taken advantage of industry resources to improve their own academic standing.

Limitations

Our study presents a focused and objective assessment on the relationship between industry funding and academic productivity of plastic surgeons. However, we do not seek to evaluate the ethics and conflicts relevant to this arrangement nor do we wish to comment on the quality of academic output produced using funds from the industry. All public-access data were extracted in October 2016, and therefore, we do expect some discordance between updated individual demographics and Center for Medicare and Medicaid Services funding data which only went as far as 2015.

Other limitations are associated with the use of h-index measures as our bibliometric of choice. The h-index can be unfairly inflated through the frequent use of self-citations. In addition, the h-index does not take into account the order of authorship. We made provisions to include other measures such as the h5-index, career publications, and total citations where appropriate in an attempt to mitigate these inherent weaknesses.[14]

A further limitation worthy of mention is the confounding effects exhibited by other funding sources acquired in association with industry funding, which collectively raise individual academic productivity. This includes federal funding, covering all aspects of scientific research such as NIH funding as well as specialized association funding such as Plastic Surgery Foundation scholarships. Consolidating total financial resources attained through all such bodies in future studies will be exceptionally valuable in determining the most influential agency driving plastic surgery research.

Conclusion

Our study demonstrated in detail the intimate association between greater industry funding and higher academic bibliometrics in academic plastic surgery fellows of every subspecialty, as well as in the general plastic surgery community. Even at modest amounts, financial support from private industry, especially when research designated, correlated with research and therefore, academic output. These trends were robust and persisted even after controlling for academic seniority. Future studies looking into federal and association funding would shed more light on the most influential sources of monetary support in the field of plastic and reconstructive surgery.

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Author contributions: Q.Z.R. conceived and designed the study; collected, analyzed, and interpreted the data; wrote the manuscript; and approved the final version of the manuscript. J.B.C. conceived and designed the study and analyzed and interpreted the data. Y.B. collected, analyzed, and interpreted the data. P.B. collected, analyzed, and interpreted the data. A.R.C. collected, analyzed, and interpreted the data. S.E. analyzed and interpreted the data. A.E.M.B. analyzed and interpreted the data. B.T.L. conceived and designed the study and analyzed and interpreted the data. All the authors provided critical revisions that are important for the intellectual content and approved the final version of the manuscript.

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