ORIGINAL ARTICLE

Evaluation of the Relative Citation Ratio, a New National Institutes of Health–Supported Bibliometric Measure of Research Productivity, among Academic Radiation Oncologists

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Abstract

Purpose: Publication metrics are useful in evaluating academic faculty for awarding grants, recruitment, and promotion. A new metric, the relative citation ratio (RCR), was recently released by the National Institutes of Health (NIH); however, no benchmark data yet exist. We sought to create benchmark data for physician faculty in academic radiation oncology (RO) and analyze correlations associated with increased academic productivity.

Methods: Citation database searches were performed for all US radiation oncologists affiliated with academic RO programs. Gender, NIH funding, career duration, academic rank, RCR, and weighted RCR were collected for each faculty. RCR and weighted RCR were calculated and compared between each subgroup of interest. RCR percentiles were also created for reference.

Results: A total of 1,299 RO physician faculty members from 75 institutions were included in the analysis. Overall, RO physician were very productive and influential with a mean RCR of 1.57 ± 1.53 SD and median RCR (interquartile range) of 1.32 (0.87-1.94). Academic rank, career duration, and NIH funding were associated with increased mean RCR and weighted RCR. Male gender and having a PhD were associated with an increased weighted RCR but not an increased mean RCR.

Conclusions: Current academic radiation oncologists have a high mean RCR value relative to the benchmark NIH RCR value of 1. All subgroups analyzed had an RCR value above 1 with professor or chair and previous NIH funding having the highest RCR and weighted RCR values overall. These data may be useful for self-evaluation of ROs as well as evaluation of faculty by institutional and departmental leaders.

Key Words: Bibliometrics, productivity, citations, relative citation ratio, radiation oncology

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INTRODUCTION

Objective measures of academic productivity are an increasingly utilized tool when awarding grants, recruiting new academic faculty candidates, and making decisions regarding promotion and tenure. Within academic medicine, residents and fellows also seek objective measures to evaluate and rank prospective programs with regard to academic output and the potential for mentorship and involvement in scholarly activities during training. Publication metrics [1-5], although imperfect, allow for evaluation and comparison of academic productivity among researchers [6-12]. Recently, the National Institutes of Health (NIH) released a new metric, the relative citation ratio (RCR) [13].

The RCR is a publication-level metric that improves on popular author-level citation indices such as the h-index [13] by utilizing the cocitation network of a particular article to normalize its impact to that of others in its field and compares the impact of a particular article against that of NIH-funded publications [13]. The use of a cocitation component ostensibly overcomes a limitation of the h-index, allowing cross-disciplinary comparison across scientific fields (eg, allowing comparison between radiation oncology and medical oncology, a much larger field). By comparison, the h-index must be contextualized relative to a given specialty or academic space to be sensible [2-5]; otherwise, high-citation academic ecosystems with many journals are compared with smaller fields, such as radiation oncology, which lack the potential citation opportunities as a function of the number of associated journals, practitioners, and specialty scope. If successful, this is obviously of value in comparison of NIH-supported researchers, because productivity of investigators from divergent fields can be judged relative to their specific publication ecosystems in a more readily interpretable manner.

The proponents of the RCR validated this metric in a data set including >88,000 publications and demonstrated that the RCR tracks well with expert opinion of research quality [13]. However, it is unknown whether this metric is applicable among specific groups within medical academia such as academic radiation oncologists (ROs). Therefore, this study aims to characterize RCR for ROs at academic institutions, to identify correlates between demographic groups and RCR, and to present RCR benchmarking information from our data set to allow for individual self-evaluation relative to academic ROs.

METHODS AND MATERIALS

Departmental and Faculty Inclusion Criteria

A list of academic radiation oncology departments was compiled by querying the website of the Association of Residents in Radiation Oncology for all programs currently accredited by the ACGME. Then, a list of clinical RO faculty was compiled from the individual department websites for each academic program [14]. Specific department websites were accessed from October to December 2016. Faculty members were classified as "clinical" if they had an MD or DO degree (ie, PhD-only faculty were not included). Gender, academic degree (PhD or no), and academic rank were also obtained from the departmental websites.

Bibliometric Analysis

A custom search was performed for each academic RO using the NIH iCite website [15]. The iCite database currently includes only PubMed-listed articles from 2002 to 2016. After the initial search for each faculty member, items categorized as nonarticles, defined by the iCite database as editorials, reviews, and meeting abstracts, were excluded. Subsequently, the total numbers of publications, mean RCR, and weighted RCR were collected. RCR-related information was collected in May 2017.

The publication-level RCR is defined as the total citations per year a publication receives divided by the average citations per year received by NIH-funded publications in the same field contemporaneously. This yields a ratio for which 1 represents the field-normalized, NIH-funded standard. For example, if a publication averages 1 citation per year and NIH-funded papers in the same field average 10 citations per year, this yields an RCR of 0.1. Author-level metrics were collected from the iCite search output, including the mean RCR for all an author's publications and the weighted RCR, defined as the sum of all an author's publication-level RCR values.

Finally, each RO was queried in Scopus (Elsevier BV, Amsterdam, the Netherlands). Academic career duration was estimated by subtracting year of first publication from 2016. This method of approximating academic career duration has been utilized in the calculation of bibliometric indices such as the m-index [16]. The NIH Research Portfolio Online Reporting Tools was queried to determine if the individual had ever received NIH funding. Career duration and NIH funding information were gathered in December 2016.

Table 1. Demographic information for US academic radiation oncologists in 2016

Demographic Characteristics	n = 1,299
Gender, n (%)	
Male	894 (69.1)
Female	399 (30.9)
PhD, n (%)	
Yes	242 (18.6)
No	1,057 (81.4)
Academic career duration (years), mean ± SD, median (IQR)*	16.9 ± 10.9, 16 (9-23)
Academic rank, n (%)	
Other† or assistant professor	759 (58.4)
Associate professor	264 (20.3)
Professor or chair	276 (21.3)
NIH funded, n (%)	
Yes	212 (16.3)
No	1,087 (83.7)
Number of publications, mean ± SD, median (IQR)‡	32.7 ± 40.9, 17 (6-45)
Mean RCR, mean ± SD, median (IQR)	1.57 ± 1.53, 1.32 (0.87-1.94)
Weighted RCR, mean ± SD, median (IQR)	52.3 ± 80.7, 18.9 (4.5-65.9)

IQR = interquartile range; NIH = National Institutes of Health; RCR, relative citation ratio.

*Estimated by year of first publication subtracted from 2016.

†"Other" indicates clinical instructors, staff physicians, or other faculty not otherwise specified.

‡Number of publications is determined using the icite.od.nih.gov database. Their database uses publications listed on PubMed between 2002 and 2016.

Statistical Analysis

RCR and weighted RCR were calculated for all academic ROs and compared by gender, degree, academic rank, academic career duration, and NIH funding. Wilcoxon and analysis of variance tests were used for between-group comparisons of two and three subgroups, respectively. RCR distributions were then calculated for all ROs, as well as compared by gender, PhD degree, academic career duration, and academic rank.

RESULTS

A total of 1,299 academic ROs were included in the analysis. The majority of academic ROs in our cohort were men (n = 894 [69.1%]), and approximately one-fifth had a PhD (n = 242 [18.6%]). The mean academic career duration was 16.9 ± 10.9 SD years. Over one-half (n = 759 [58.4%]) of academic ROs in our cohort had an academic rank of assistant professor or other (clinical instructor, staff physician, or faculty member not otherwise specified). A minority had received NIH funding in the past (n = 212 [16.3%]). The mean number of publications was 32.7 ± 40.9 SD. Further demographic details are provided in Table 1.

Overall, academic ROs had high mean RCR values (mean 1.57 ± 1.53 SD) and median of 1.32 and interquartile range (IQR) of 0.87 to 1.94. Additionally, academic ROs had high but widely variable weighted RCR values (mean 52.3 ± 80.7 SD, median 18.0 [IQR 4.5-65.9]).

Comparisons between RCR values and weighted RCR are included in Table 2. Men had a significantly higher weighted RCR compared with women (median 23.0 [IQR 4.8-77.0] versus 12.9 [4.0-42.4]; $P = .0002$), but the mean RCR was similar. Having a PhD was also not associated with a significantly increased mean RCR but was similarly associated with an increased weighted RCR (median 27.1 [IQR 9.2-70.4] versus 16.9 [3.7-64.9]; $P = .0007$). Academic career duration, academic rank, and prior NIH funding were strongly correlated with mean RCR and weighted RCR (all $P < .0001$; Table 2).

Percentiles for all publications, as well as benchmark NIH-funded publications, are listed on the iCite website under the statistics section. Of all PubMed-listed publications included in the iCite database, the median RCR was 0.37. The 10th percentile RCR was 0, and the 90th percentile was 2.24. By definition, the median RCR for all NIH-funded publications was 1.00. The 10th percentile RCR for NIH-funded publications was 0.38, and the 90th percentile was 3.81. In contrast, the median RCR for work published by all academic RO was 1.32. The 10th percentile RCR for academic RO publications was 0.30, and the 90th percentile was 2.82. Additional percentiles were calculated for all ROs as well as various subgroups of academic ROs (Table 3).

DISCUSSION

In this benchmark analysis of RCR among academic ROs, we found a strong correlation between having a PhD, a longer academic career duration, an academic rank of associate or full professor, and previous NIH funding with an increase in both mean and weighted RCR. These findings mirror prior correlations found with h-index and similar subgroups of academic ROs [1-3].

Table 2. Mean and weighted relative citation ratio values for US academic radiation oncologists in 2016

Subgroups	Mean RCR, Mean ± SD, Median (IQR)	*P* Value‡	Weighted RCR, Mean ± SD, median (IQR)	*P* Value‡
Gender		.786		.0002
Male	1.56 ± 1.32, 1.32 (0.88-1.94)		57.62 ± 84.50, 23.04 (4.84-77.01)	
Female	1.56 ± 1.92, 1.32 (0.87-1.94)		39.62 ± 68.80, 12.89 (3.98-42.36)	
PhD		.070		.0007
Yes	1.73 ± 1.47, 1.35 (1.00-2.03)		55.10 ± 78.23, 27.14 (9.16-70.44)	
No	1.53 ± 1.54, 1.32 (0.85-193)		51.62 ± 81.31, 16.85 (3.72-64.90)	
Academic career duration (years)*		<.0001		<.0001
≤16	1.43 ± 1.66, 1.19 (0.80-1.68)		26.12 ± 40.85, 11.57 (3.24-28.94)	
>16	1.71 ± 1.36, 1.47 (0.97-2.16)		80.48 ± 101.10, 40.62 (8.09-120.86)	
Academic rank		<.0001		<.0001
Other† or assistant professor	1.42 ± 1.71, 1.16 (0.68-1.72)		25.33 (51.64), 9.01 (2.07-24.34)	
Associate professor	1.55 ± 1.20, 1.38 (0.94-1.85)		52.19 (60.07), 30.61 (10.63-68.60)	
Professor or chair	1.97 ± 1.16, 1.76 (1.26-2.45)		126.45 (111.51), 96.75 (40.68-178.75)	
NIH funded		<.0001		<.0001
Yes	2.06 ± 1.34, 1.75 (1.26-2.54)		120.88 ± 115.32, 92.24 (38.52-173.36)	
No	1.47 ± 1.54, 1.23 (0.81-1.84)		38.89 ± 64.09, 13.46 (3.38-43.36)	

Weighted RCR = sum of all RCR/total publications; NIH = National Institutes of Health; IQR, interquartile range; RCR = relative citation ratio (citation rate/benchmark citation rate).

*Estimated by year of first publication subtracted from 2016.

†"Other" indicates clinical instructors, staff physicians, or other faculty not otherwise specified.

‡*P* value using the Wilcoxon test in comparing means of two groups and analysis of variance when comparing means of three groups.

The initial bibliometric benchmarking study among academic ROs performed in 2007 included 826 faculty members and utilized the h-index as the metric of interest. A higher h-index was associated with senior faculty status and male gender. However, when stratifying by academic rate, the gender differences in h-index disappeared. Recursive partitioning analysis revealed an h-index threshold of 15 as a significant breakpoint between junior and senior faculty, suggesting h-index may be a useful objective metric for promotion and tenure [2]. An update to this cohort was performed in 2012, at which time there were 1,037 academic RO faculty included. Multivariate analysis showed academic rank, male gender, and large department size were all independently associated with a higher h-index. A threshold h-index of 20 was found between junior and senior faculty, suggesting that the academic productivity of academic ROs overall had increased [3]. The most recent update to this cohort was published in 2017 and showed academic rank, departmental size, and NIH funding to be independently associated with a higher h-index among the 1,191 academic RO faculty included. The threshold h-index was found to be 21 between junior and senior faculty, which is more consistent with the 2012 data [1].

The fact that RCR correlates with similar faculty characteristics, as does h-index, lends validity to this new metric. In addition to academic rank and prior NIH funding, the current study showed that having a PhD and having a longer career duration were both significantly associated with a higher RCR. These relationships stand to reason given the dependence of RCR on the gold standard of NIH-funded publications within a given field. RCR has potential advantages over indices such as the h-index, including being easier to translate and compare across institutions and specialties. The two main criticisms of the h-index have been that it is both time and field specific. The h-index is not able to distinguish between current, impactful scholastic activity and retired academicians who published a few highly cited works early in their careers. Additionally, the h-index lacks the granularity to explain how the h-index applies specifically to different fields of science [17,18]. Although the RCR is still a relatively new metric, we welcome further benchmarking studies in other specialties to evaluate its broad applicability. It is encouraging that it is both time and field normalized to overcome the most often-cited shortcomings of the most popular bibliometric index.

Table 3. Percentiles for relative citation ratio–specific subgroups

Subgroups	Percentile											
	99.9	99	95	90	80	70	60	50	40	30	20	10
All publications*	23.62	7.98	3.45	2.24	1.31	0.86	0.57	0.37	0.22	0.10	0.00	0.00
All NIH-funded publications	38.00	13.11	5.72	3.81	2.39	1.72	1.30	1.00	0.76	0.56	0.38	0.20
All academic RO publications	26.48	6.48	3.64	2.82	2.11	1.77	1.52	1.32	1.12	0.98	0.75	0.30
Gender												
Male	12.13	6.69	3.65	2.79	2.11	1.75	1.51	1.32	1.13	0.98	0.76	0.32
Female	32.63	6.00	3.51	2.91	2.09	1.83	1.52	1.32	1.11	0.96	0.73	0.27
PhD												
Yes	10.32	8.93	4.84	3.09	2.26	1.74	1.56	1.35	1.18	1.07	0.89	0.50
No	31.44	6.00	3.49	2.74	2.09	1.78	1.51	1.32	1.11	0.95	0.70	0.21
Academic career duration (years)†												
≤16	32.63	6.25	3.54	2.56	1.89	1.57	1.39	1.19	1.05	0.90	0.63	0.18
>16	12.13	7.37	3.89	3.00	2.38	2.00	1.72	1.47	1.27	1.05	0.87	0.44
Academic rank												
Other or assistant professor	32.63	6.69	3.64	2.63	1.94	1.59	1.35	1.16	1.00	0.85	0.52	0.00
Associate professor	12.13	6.05	3.53	2.60	1.97	1.70	1.55	1.38	1.17	1.01	0.83	0.51
Professor or chair	9.74	6.89	4.01	3.19	2.63	2.27	1.96	1.76	1.49	1.34	1.15	0.92

NIH = National Institutes of Heath; RO = radiation oncologist.
*Number of publications is determined using the icite.od.nih.gov database. Their database uses publications listed on Pub Med between 2002 and 2016.
†Estimated by year of first publication subtracted from 2016.

Interestingly, our findings also suggest the publication of academic ROs was relatively influential compared with the general scientific literature as evidenced by RCR values well above the benchmark ratio of 1. Because the iCite website is free and publically available, anyone can obtain an individual's RCR values. The RO benchmark percentile table (Table 3) for various subgroups of RO faculty may be interesting or useful for individuals and departmental and institutional leaders.

This study provides valuable benchmark data for academic ROs; however, it is not without limitations, particularly those inherent to the RCR itself. One is the elapsed time between RCR data collection and the date of ultimate publication of this work. The mean and weighted RCR values are subject to dynamic change and are updated frequently in iCite. The iCite website does not differentiate between individuals with the same name, which can lead to errors. Another potential source of error is RO faculty publishing under different names, such as in the event of a name change after marriage or divorce. Prior work has shown that approximately 12% of academic ROs change their name at some point during their academic career [19]. Therefore, this has the potential to artificially lower the RCR values for women disproportionately compared with men. In addition, only PubMed-listed publications from 2002 to 2016 are currently available in iCite. Therefore, results underrepresent the RCR for faculty who did a large volume of work before 2002. Finally, because the benchmark RCR is calculated from NIH-funded research, this metric has limited applicability outside the United States.

In conclusion, the RCR helps to overcome some of the weaknesses of other productivity indices. We have established benchmark radiation oncology tables that allow anyone to compare his or her mean RCR and weighted RCR values with other academic ROs. We hope these data may be useful for individuals for self-evaluation as well as for leadership seeking to evaluate current and potential faculty.

TAKE-HOME POINTS

- This is the first study to analyze RCR metrics with regards to a specific academic medical field.
- For academic ROs, there is a strong correlation between having a PhD, long career duration, advanced academic rank, and previous NIH funding with an increased mean RCR and weighted RCR.
- This study established benchmark radiation oncology tables that provide metrics to compare an individual physician-scientist's mean RCR and weighted RCR values with other academic RO.

- The RCR may be a useful metric for self-evaluation of ROs as well as in evaluation of faculty by institutional and departmental leadership.

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