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Clinical Investigation

Success Breeds Success: Authorship Distribution in the Red Journal, 1975-2011

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Summary

Since Lotka initially described the relationship between the number of authors and the number of articles they publish, investigators in many fields have attempted to apply his law to their own literature. We performed a bibliometric analysis of authorship distribution in the Red Journal and found that the majority of publications in the field of radiation oncology are produced by a small, highly productive group of authors. Additionally, we explore possible reasons for this finding.

Purpose: Publication analysis has value in evaluating the mechanics of academic efforts in specific scientific communities. The specific aim of this study was to evaluate whether established bibliometric patterns seen in other academic fields were likewise observed in radiation oncology publication parameters.

Methods and Materials: We used a commercial bibliographic database to analyze all publications in Red Journal, or *International Journal of Radiation Oncology Biology Physics* (IJROBP), the *New England Journal of Medicine* (NEJM), the *Journal of Clinical Oncology* (JCO), and *Radiology* (Rad) between January 1, 1975 and May 18, 2011. Power-law (Lotka's law or $1/n^2$) conformance was assessed. Curve fit analysis was then performed.

Results: In all 4 journals, a total of 219,476 authors were responsible for 62,232 articles. Of those, 79,810 authors published 13,772 articles in IJROBP, with 79,446/16,707 authors/articles in NEJM, 106,984/11,920 authors/articles in JCO and 90,325/19,745 authors/articles in Rad. The mean $\pm$ standard deviation of authors per publication was 5.74 $\pm$ 4.61 overall. There were 5.8 $\pm$ 3.53, 4.8 $\pm$ 5.7, 8.9 $\pm$ 3.53, and 4.6 $\pm$ 2.8 authors per article in IJROBP, NEJM, JCO, and Rad, respectively ($P<.001$). The number of authors publishing n articles was $1/n^{2.02}$ of those publishing 1 article in IJROBP, $1/n^{2.52}$ in NEJM, $1/n^{1.97}$ in JCO, and $1/n^{2.16}$ in Rad.

Conclusions: Bibliometric analysis shows that authorship distributions in IJROBP approximate those of the scientific literature in comparable scientific journals. Our results suggest that the majority of publications in the field of radiation oncology are produced by a small but highly productive group of authors. © 2012 Elsevier Inc.

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Introduction

Within bibliometric analysis, it is a well-established observation that the majority of scientific contributors proffer no more than 1 manuscript, and that a small but active percentage of authors are disproportionately productive. Lotka's Law summarizes this observation, stating that the number of authors making n contributions is equal to about $1/n^L$ of those publishing 1 article, where L is approximately 2. Therefore, the percentage of all contributors contributing a single article is approximately 60%, the percentage contributing 2 articles is 15%, and so on. Alfred Lotka originally described this relationship by analyzing publications in the *Decennial Index to Chemical Abstracts 1907-16* and *Auerbach's Geschichtstafeln der Physik* submitted by chemists and physicists in the early 20th century (1).

Since this original publication in 1926, many academic fields have attempted to apply this power law to publication productivity. Obstetrics and gynecology, neuroscience, dental science, psychiatry, and epidemiology have all attempted to apply Lotka's Law to authorship distributions within their respective fields (2-7). Most investigators have found that authorship rates abide by Lotka's Law whether analyzed by field (2-4), journal (7), or subject matter (5, 6). The wide applicability of this bibliometric phenomenon suggests that it may also provide insight into other competitive human activities.

Other surrogates have been used to evaluate and compare academic productivity in the field of radiation oncology. Choi et al evaluated the productivity of radiation oncologists using the Hirsch index and found a breakpoint, h = 15, separating junior and senior faculty (8). Morgan et al evaluated first-authorship rates among radiation oncology residents and ranked residency programs based on productivity (9). To our knowledge, there are no currently published studies examining authorship distribution in a single medical journal, or in radiation oncology specifically.

This study aimed to tabulate authorship statistics in a major radiation oncology journal, the *International Journal of Radiation Oncology Biology Physics* (IJROBP), as part of a larger effort to quantify academic field-specific parameters of scientific activity so as to determine a baseline metric for future comparison. To this end, we sought to assess bibliometric patterns in academic field-specific journals in similar, related specialties and in prominent cross-disciplinary journals. Specifically, we used a primary diagnostic radiology journal, *Radiology* (Rad); an oncology journal, the *Journal of Clinical Oncology* (JCO); and a high-impact medical journal attracting authors across disciplines, the *New England Journal of Medicine* (NEJM). Additionally, we wished to determine whether authorship distribution(s) in said journals approximate Lotka's Law. We aimed to examine other trends in authorship including the percentage of articles written by a single author and the mean number of authors per article. Finally, we aimed to identify, albeit in a limited fashion, the characteristics of individuals with the highest publication rates in IJROBP and to discuss the potential implications of these observations.

Methods and Materials

The journals chosen for bibliometric analysis were IJROBP (ISSN 0360-3016), NEJM (ISSN 0028-4793), JCO (ISSN 0732-183X), and Rad (ISSN 0033-8419).

A search was performed using a commercial bibliographic database (SCOPUS, Elsevier B.V., Amsterdam, Netherlands). All publications from 1975, or earliest publication if the journal was founded after 1975, until May 18, 2011, as reported in SCOPUS, were downloaded and compiled in a spreadsheet as comma-separated-values. All publications appearing in SCOPUS during the aforementioned time period were initially considered for the purpose of this analysis. This included letters to the editor, commentaries, and invited review articles in addition to peer-reviewed publications. "Articles," as so labeled in SCOPUS, were extracted separately from other documents (eg, conference papers, erratum, letters, notes, reviews, and short surveys). Additionally, we disregarded a total of 4016 publicationswritten by groups or corporations with no author specified in SCOPUS: 274 in IJROBP, 2255 in NEJM, 122 in JCO, and 265 in Rad. We relied on SCOPUS documentation as to whether a publication was an "article" as opposed to other document types (eg, review, letter, erratum). The number of article coauthorships credited to each author in each journal was determined, giving all coauthors listed in the title lines equal credit for the article.

Authorship analysis and tabulation were performed by journal and authorship frequency in articles. The mean authors per article in each journal were compared by analysis of variance.

Lotka's Law conformance was tested graphically as the log A_1/A_n was then plotted against the log of n, where A_1 was the number of authors publishing 1 article and A_n was the number of authors publishing n articles, and fit to a slope of $1/n^L$, where L was compared with Lokta's value of 2. An equivalent curve fit was performed using collected citation data, creating an estimation of L, with confidence interval calculation. Fit comparison was performed with JMP software (JMP, Version 7. SAS Institute Inc, Cary, NC). Finally, the distinct number of publications per author in IJROBP was tabulated, and the top 10 most prolific authors were identified.

Results

A total of 219,476 authors were responsible for 109,733 publications in all 4 journals (including articles, conference papers, errata, letters, notes, reviews, and short surveys). Of those, 79,810 authors published 18,779 publications in IJROBP, 79,446 published 48,249 publications in NEJM, 106,984 published 18,269 publications in JCO, and 90,325 published 19,745 publications in Rad. After the exclusion of conference papers, editorials, errata, letters, notes, reviews, and short surveys, there were 62,232 articles published in all 4 journals. We found that 79,810 authors published 13,772 articles in IJROBP, 79,446 authors published 16,707 articles in NEJM, 106,984 authors published 11,920 articles in JCO, and 90,325 authors published 19,745 articles in Rad.

Figure 1 shows the number of authors publishing 1-10 articles in each journal. When evaluated as a percentage of the total number of 219,476 authors for all 4 journals, 60.1% of authors published 1 article total in any 1 of the journals studied (IJROBP, NEJM, JCO, or Rad) during the time period from 1975-May 18, 2011.

The percentage of authors publishing only a single article in IJROBP was 62.9%, compared with 77.1%, 62.8%, and 67.0% for NEJM, JCO, and Rad, respectively ($P<.001$). Figure 2 shows the percentage of all authors publishing 1 through 10 articles in each journal.

Lotka's model gave a good fit when applied to each journal; the estimated exponents of 2.02, 2.52, 1.972, and 2.16 for were

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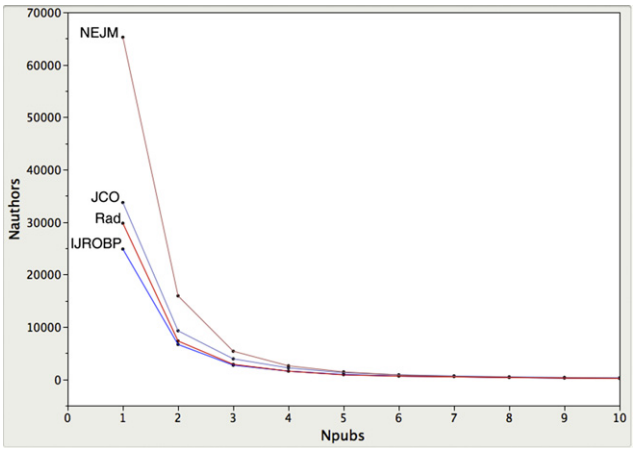

Fig. 1. Number of authors publishing 1-10 articles by journal. IBROBP = International Journal of Radiation Oncology Biology Physics; NEJM = New England Journal of Medicine; JCO = Journal of Clinical Oncology; Rad = Radiology.

calculated for IJROBP, NEJM, JCO, and Rad, respectively. The Table shows the estimated Lotka's exponent L with confidence intervals and approximate standard errors. Inasmuch as Lotka's exponent for all journals studied approximated 2, the number of authors publishing 2 article in the various compared journals approximates $1/2^2$ (25%) of the number of authors publishing 1 article. Likewise, the number of authors publishing 3, 4, and 5, articles, respectively, is $1/3^2$ (11.1%), $1/4^2$ (6.25%), $1/5^2$ (4%) of the number of authors publishing a single article.

For all journals studied, the mean authors per article was 5.74 ± 4.61, and the number of authors per article ranged from 1 to153. The mean number of authors per article differed significantly among the 4 journals. JCO had the highest mean authors per article, with 8.9 ± 4.98, and Rad had the lowest mean authors per article, with 4.6 ± 2.8. IJORBP and NEJM had means of 5.8 ± 3.53 and 4.8 ± 5.7 authors per article, respectively.

A *post-hoc* graphic analysis performed on this dataset suggests that, as expected, career publishing duration (eg, time from initial

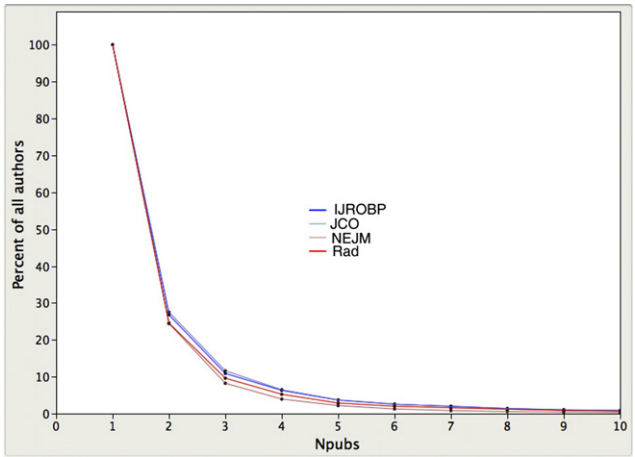

Fig. 2. Percentage of total authors publishing 1-10 articles by journal. IBROBP = International Journal of Radiation Oncology Biology Physics; NEJM = New England Journal of Medicine; JCO = Journal of Clinical Oncology; Rad = Radiology.

authorship/coauthorship in a journal) was positively correlated with the number of publications (Fig. 3a).

Likewise, an additional *post-hoc* analysis demonstrated that, for those with multiple authorship/coauthorship, the number of publications per year increased as a correlate of interval between first and latest publication year, in such a manner that although those with a publication interval <5 years had an annualized publication rate of 1.1 articles per year, those with >20 years had a publication rate of 1.4 (*post-hoc* $P<.001$ with Tukey's honestly significant difference test). In the Red Journal specifically, the mean annualized publication rose from 1.15 publication/year for those early in their careers to 1.6 for those with more than 20 years of publishing experience in IJROBP (Fig. 3b).

Figure 4 outlines the mean IJROBP publications per author by year. Interestingly, between 1991 and 1992, a small number of investigators (n = 17) served as authors or coauthors on a staggering 185 distinct publications out of 1067. The author concentration in the Red Journal before and since this period has never seen such a "concentration spike," inasmuch as during this 2-year interval these authors, though constituting only <0.1% of authors, nonetheless contributed to 17% of all published IJROBP articles during that span.

Discussion

To our knowledge, this study represents the first bibliometric analysis of authorship rates in a major radiation oncology, oncology, or radiology journal. We found that authorship in IJROBP does approximate Lotka's Law, and publication distribution is similar to that of major journals in the fields of radiology, oncology, and general medicine. One interesting observation is that the percentage of authors publishing 1 article vs 2, 3, and so on does not seem to vary substantially with the number of authors or publications between radiology, oncology, or radiation oncology journals analyzed. Although 63,508 authors each published 1 article in NEJM whereas only 22,009 each authors published 1 article in IJROBP, the single-paper authorship percentages were statistically distinct at 68% and 59.4% (*post-hoc* Fischer's exact test, $P<.001$), respectively, despite the fact that NEJM published, on average, twice as many annual articles per year (mean ± SD 1310 ± 210) compared with IJROBP (520 ± 219). This differs from the observation by Kawamura et al of dental science literature that the percentage of authors with multiple publications *increases* with the number of annual publications in a journal (4). This discrepancy may be due to the high impact factor of NEJM and its large international readership, raising the bar for multiple article authorship in a more competitive cross-discipline journal.

Kawamura et al found that the authorship distribution in dental science literature approximated Lotka's Law, with L = 1.95 overall; the range by journal was 1.86-3.57 (4). Our data show Lotka's exponent estimates to approximate 2 for each of the 4 journals studied, suggesting that authorship distribution as a whole in IJROBP follows a pattern of distribution similar to that in journals in other specialties and in a higher-impact journal with broader appeal across multiple specialties.

The significant differences in terms of the mean number of authors per article and the percentage of articles written by a single author also introduce an interesting point of comparison between IJROBP, NEJM, JCO, and Rad. NEJM has the lowest mean number of authors per article and a percentage of articles written by a single individual that is more than double that of any

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Table Lotka's Law estimate by journal

Journal	Lotka's Law estimate (L)	Confidence interval	Approximate standard error	Goal standard square error	Convergence criterion
IJROBP	2.020	2.015-2.026	0.003	0.01	0.05
NEJM	2.523	2.500-2.555	0.014	0.01	0.05
JCO	1.973	1.957-1.989	0.008	0.01	0.05
Rad	2.164	2.156-2.171	0.004	0.01	0.05

Abbreviations: IBROBP = International Journal of Radiation Oncology Biology Physics; NEJM = New England Journal of Medicine; JCO = Journal of Clinical Oncology; Rad = Radiology.

other journal studied. Larsen and von Ins (10) found that the increasing trends of interdisciplinary collaboration and multiple authorship within the scientific community in the 1990s and 2000s have not changed the fundamental principles of productivity and publication distributions.

In all 4 journals studied, the individuals publishing the most articles were, in many cases, either current or past editors. The Supplementary Table E1 outlines the characteristics of the individuals publishing the 10 greatest numbers of articles in the IJROBP (www.redjournal.org).

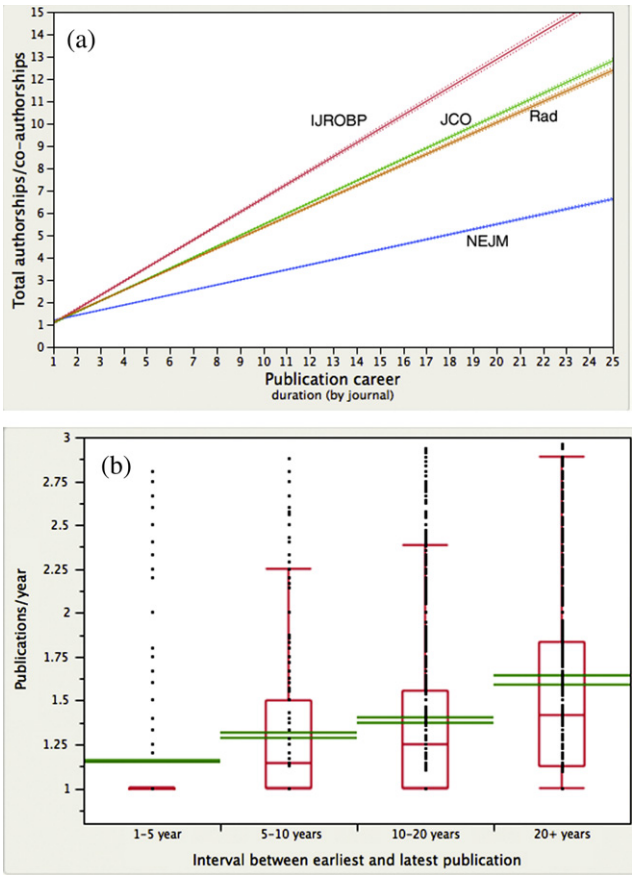

Fig. 3. (a) Linear fit with shaded confidence interval, of authorship number plotted against publication career duration (eg, interval between earliest and latest authorship in said journal). (b) Quartile boxplot (*in red*) of annualized individual IJROBP article publication rate by publication career duration, for authors in >1 article; mean confidence interval lines shown in green. IBROBP = International Journal of Radiation Oncology Biology Physics; NEJM = New England Journal of Medicine; JCO = Journal of Clinical Oncology; Rad = Radiology.

At the journal level, time factors may also play a role. Saam and Reiter (11) analyzed the temporal evolution of publications of 5 different journals in mental health fields, and they postulated that as a "successful" journal is created, initially a "core" concentration of authors predominates; over time, the contributor base broadens until it reaches equilibrium. Unsuccessful journals, by contrast, do not attract new authors and may eventually stop being published. Consequently, the diffusion of publication concentration might then serve as a metric for increased appeal. Interestingly, analysis of the mean number of publications per author (as a surrogate for author concentration) shows that the Red Journal has actually consolidated authorship over time.

Not surprisingly, we found that the number of publications in the Red Journal, as in the other journals studied, increases with career duration (Fig. 3a and b). This suggests that persistence of publication, rather than supernatural talent, may be a key feature of publishing multiple articles. Thus, efforts to increase productivity may have more to do with policies and practices that encourage duration of scientific participation (e.g., mid-career mentorship). Especially interesting is the fact that author concentration, as assessed by mean publications per author, was markedly higher than normal in the period from 1991-1992 (Fig. 4). Although the cause of this phenomenon is unknown, potential contributing factors include a greater mean number of authors per article during this time period, indicating a greater degree of collaboration, a greater concentration of research funding during this time period allowing for certain groups to be more productive than others. Additionally, we cannot exclude the influence of bias on the part of reviewers during this time period. Although the Red Journal currently uses a double-blind review process to help prevent bias and nepotism, this has not always been the case. Without review of all submitted manuscripts to the Red Journal during this time period in addition to those that were actually published, it is difficult to fully explain this finding.

For a small specialty journal such as IJROBP, it may be worthwhile to reflect periodically on such publication patterns to ensure that a small number of productive participants do not render a journal into an insular "echo chamber" of the same rotating author cohort. For whatever reason, the manifested "spike" has not been seen since; however, detection of such patterns is apparent only with periodic observation.

The major strengths of this study include our data acquisition and analysis methods. All the publication data, including author names, were uploaded directly from the SCOPUS website into a database by 1 person (EHR) to ensure consistency. The data

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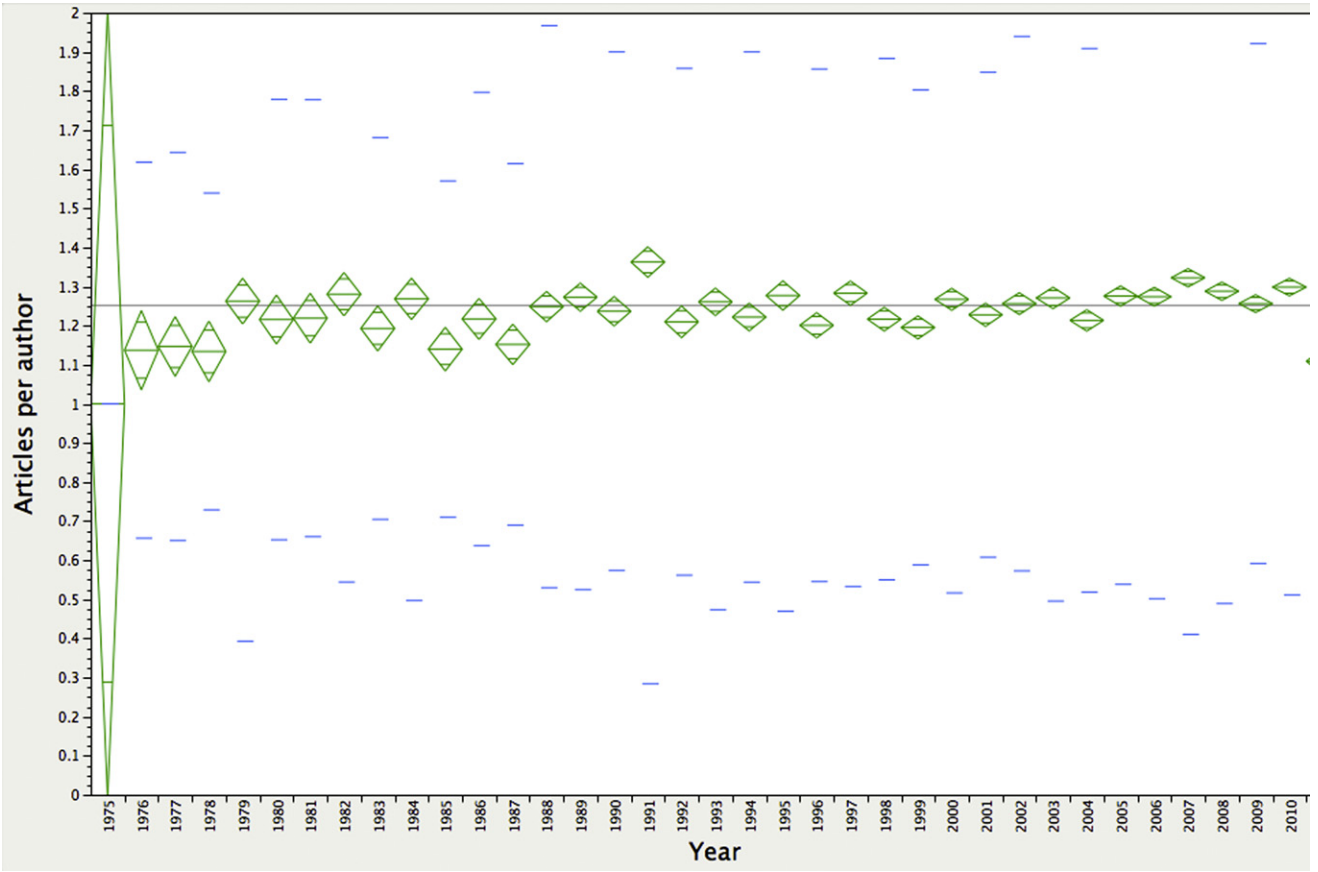

Fig. 4. International Journal of Radiation Oncology Biology Physics publication "concentration spike" of 1991-1992. Plot of cumulative number of attributed articles per author per year. The confidence interval of the mean number of publications per contributor per year is shown, with 95% confidence interval of the mean as lines in green.

from all 4 journals were also acquired in a single day to avoid discrepancies due to rolling updates by SCOPUS. However, the actual number of publications attributed to each author is subject to change between the times of data acquisition and publication. There are several inherent limitations to a bibliometric study with a scale of this magnitude. In the gross tabulation of data, citations were disregarded if they were "in press" but not yet listed in PubMed. Another potential source for error was authors publishing under different names. This occurs when an author changes a name after marriage or simply includes a previously omitted middle initial and/or suffix. Conversely, if 2 authors share a name, the number of publications attributed to that author might be falsely high. Additionally, in this analysis, we did not consider authorship order when calculating the L estimate. In Lotka's original work, only senior author was included in the calculation of L. Conceivably, both the "single authorship" rate and the L value would have been higher if only first or senior authorship had been considered.

The publication distribution in IJROBP reinforces what can be observed in the field of radiation oncology as a whole. There is a large group of people who will each publish 1 article, perhaps as a requirement for residency (9) or as part of an isolated collaborative project. The number of people continuing on an academic career path decreases, with even fewer having the time, funding, and/or interest to publish multiple articles. It follows that the topics for discussion within a field are determined, or at least guided, by a select few. With publication distributions of so many journals, specialties, and fields abiding by Lotka's Law (12-17), is the authorship distribution something we can change, as Saam and Reiter suggest (11)? Or does this pattern represent a macrophenomenon inherent to competitive human activity when modeled using exponential functions, as per Huber (18)?

Even if we cannot change this inherent pattern of publication distribution, it is still important to recognize and record it. If we are interested in furthering the productivity and increasing the number of publications in the field of radiation oncology as a whole, only a few avenues are available to us. Given the finite amount of existing academic positions and research dollars, increasing the total number of authors in the pool seems an unlikely option. Another choice is to dedicate even more support and resources to those superproductive individuals who have already shown they can be successful in generating large numbers of publications. Last, and potentially where the field of radiation oncology has the greatest opportunity for gain in total publication productivity, we can "raise the tail" of the distribution curve. This would require mentorship and outreach to encourage more people to publish 2 or 3 articles instead of 1 and to increase the diversity of voices participating in the greater discussion of academic radiation oncology.

Conclusions

We have demonstrated through bibliometric analysis that authorship distributions in radiation oncology journals approximate

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those of the scientific literature at large and of power-law relationships generally. Our results suggest that publications in the field of radiation oncology and in other disciplines are produced by a relatively small but highly productive subset of authors.

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