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Using Bradford's law of scattering to identify the core journals of pediatric surgery

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ABSTRACT

Background: Bradford's law of scattering defines an exponentially diminishing return when extending a search for references in journals and can be used to identify the "core" journals in a field. The purpose of this study was to identify the core journals of pediatric surgery.
Methods: With Institutional Review Board approval, we developed bibliometric profiles for the top academically productive pediatric surgeons in the United States. These profiles included the total number of publications, journals in which those authors published their manuscripts, and identification of all articles cited by those surgeons, along with the journals those references were drawn from. Bradford's law of scattering was applied to identify the core journals of pediatric surgery.
Results: We identified $n = 69$ pediatric surgeons (10 ± 0.2 5-year h-index). These authors published 10,031 articles (145 ± 90 per surgeon), which were cited 250841 times (3635 ± 413 per surgeon). Pediatric surgeons' articles contained 199507 references (2891 ± 176 per surgeon). We analyzed 58,310 references (top 20 journals) cited by pediatric surgeons. Bradford's Law identified a single core journal for p = 3-10 zones, with $P = 3$, providing the best correlation between predicted and actual values ($R2 = 0.9996$). The core journal for pediatric surgery is *Journal of Pediatric Surgery*.
Conclusions: We used Bradford's Law to identify the core journals of pediatric surgery. These core journals include the two leading pediatric surgery–specific journals and the highest impact factor journals in surgery (*Annals of Surgery*) and medicine (*NEJM*). These findings can help busy pediatric surgeons focus their reading to stay updated in a rapidly evolving field.

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Introduction

Evidence-based practice is a critical component of modern health-care delivery. The practice itself not only promotes the best medical and surgical practices but can also contribute to decreasing health-care costs.[1] It has become such an integral part of surgical education as well that the American College of Surgeons has established an evidence-based decision program for common surgery procedures.[2] However, every decade, the amount of scientific literature from which one can draw evidence has increased exponentially. The plethora of information can be overwhelming to trainees and practicing surgeons. Thus, one of the ways to cope with the advancing information is to regularly read journal articles focused on the respective subspecialty. However, due to the rapid increase in information, there are many journals one can chose from to learn about the advances in the field. While this problem may seem most burdensome for large specialties, smaller subspecialties like pediatric surgery also face the same problem. Thus, there is a need to identify a list of core journals in which the most up-to-date and relevant articles are published.

Bradford's law of scattering was developed in 1934 and states, "if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same articles as the nucleus, when the number of periodicals in the nucleus and succeeding zones will be as 1: n: n^2, where "n" is a multiplier".[3,4] In other words, this describes how the work in a subject can be organized into zones that have the same number of articles as the "core". These zones signify the level of importance. To illustrate, the core zone is a small group of journals that has the most relevant articles that are widely cited (Fig. 1). As the number of zones increases, it is less likely that the journals in those zones publish articles that are widely cited.

Bradford's Law has been used to organize literature in multiple fields. Recently, the law has been applied to distribute journals in neurosurgery,[5-7] bariatric surgery,[8] and rheumatology.[9] However, the law of scattering has yet to be applied to the field of pediatric surgery, where the distribution of published articles is separated into pediatric, surgical, medical, and obstetric journals. Thus, there is a need to establish core journals where trainees and practicing pediatric surgeons can reference to find articles relevant to pediatric surgery. The goal of this study was to identify the core journals in pediatric surgery. We hypothesized that there would be several core journals, with the primary focus being on pediatric surgery.

Methods

Ethics statement

This study was approved by the Institutional Review Board of the University of Tennessee Health Science Center.

Study population and bibliometric profiles

We have previously described the generation of bibliometric profiles for academic pediatric surgeons and pediatric surgery training programs.[10] Briefly, the 48 United States pediatric surgery fellowship training programs were identified, and each institutions' website was used to identify board-eligible/certified pediatric surgeons ($n = 434$). Elsevier's Scopus was used to obtain each surgeon's complete bibliographic record. All searches were conducted in January-March 2017. From this list, surgeons ($n = 69$) whose 5-year h-index was greater than one standard deviation above the mean were identified as the top academically productive pediatric surgeons in the United States. The following information was then extracted for each of those authors: total number of publications, total number of

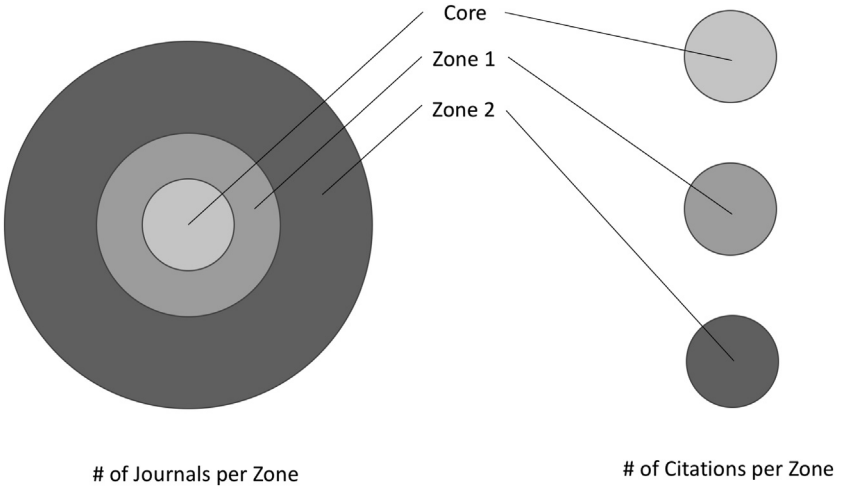

Fig. 1 – Schematic representation of Bradford's law of scattering. On the left, the number of journals present in each zone is indicated with progressively enlarging zones. On the right, the number of citations represented in each zone is depicted. The number of citations in each zone is constant, while the number of journals required to find those citations increases exponentially.

citations within the last 5 y, and the journals in which those authors published their manuscripts (along with frequency). The final level of analysis involved identification of all of the journals referenced within each article published by pediatric surgeons.

Bradford's law of scattering

Bradford's law of scattering can be used to describe a subject as a series of zones, starting with a "core" and progressing outward, such that the number of relevant articles in each zone is equal to the core, but an increasing number of journals is found in each zone to account for those articles of relevance (Fig. 1). The number of journals found in each successive zone can be defined as c: ck: $ck^2 \ldots ck^{p-1}$, where c is the number of journals in the core zone, k is the Bradford multiplier between zones, and p is the number of zones. The number of zones (p) typically has a minimum of three, maximum of 10, and each field has its own values for c and k. The values of c and k are dependent on the choice of p, or number of zones, and can be calculated using the following equations:

$$k = (e^{\gamma} Y_m)^{1/p}$$
$$c = T(k-1)/(k^p - 1)$$

In these equations, e is Euler's number (2.71828), and γ is Euler's constant (0.57721). Y_m is the number of citations in the highest ranked journal, and T is the number of journals being analyzed. Each zone of journals will theoretically contain the same number of citations (total citations divided by number of zones). The observed versus theoretical distribution can be compared to identify the appropriate number of zones for the given field. Alternatively, the total number of citations (A) can be divided by the number of zones (p) to give the expected number of citations per zone (verbal formulation of Bradford's Law), and this is compared with the actual distribution.

Statistical methods

Descriptive statistics are used to describe the bibliometric profiles. Pearson's correlation coefficient was employed to compare actual versus theoretical distributions of Bradford's Law. A P-value <0.05 was considered significant. All statistics were performed using Microsoft Excel (Redmond, WA).

Table 1 – Bibliometric profiles for the top 69 academically productive US pediatric surgeons.

Bibliometric parameter	Value (mean ± SEM)
5-year h-index	10 ± 0.2
Lifetime h-index	28 ± 1.4
Number of articles published	145 ± 90 (10,031 total)
Number of times the surgeon was cited	3635 ± 413 (250,814 total)
Number of articles each surgeon cited	2891 ± 176 (199,507 total)

Results

Bibliometric profile of the top academically productive US pediatric surgeons

Complete bibliometric profiles for academic pediatric surgeons and pediatric surgery training programs in the United States were previously generated.[10] From this list of surgeons ($n = 434$), we identified $n = 69$ surgeons whose 5-year h-index was greater than one standard deviation above the mean for further analysis (Table 1). These authors published 10,031 articles which were cited 250841 times. The average h-index for the top authors was 28 ± 1.4 and 10 ± 0.2 for the lifetime and 5-year indices, respectively. The average number of articles

Table 2 – Top 20 journals in which pediatric surgeons published their research.

Journal	Number of documents	Cumulative % of all documents
Journal of Pediatric Surgery	2809	26.96%
Journal of Surgical Research	370	30.51%
Pediatric Surgery International	358	33.95%
Seminars in Pediatric Surgery	214	36.00%
Annals of Surgery	188	37.81%
Journal of Laparoendoscopic and Advanced Surgical Techniques	165	39.39%
Surgery	158	40.91%
Pediatrics	154	42.38%
Fetal Diagnosis and Therapy	139	43.72%
American Journal of Surgery	123	44.90%
Journal of The American College of Surgeons	119	46.04%
Journal of Trauma Injury Infection and Critical Care	110	47.10%
Pediatric Radiology	84	47.90%
Archives of Surgery	83	48.70%
European Journal of Pediatric Surgery	79	49.46%
Journal of Pediatrics	78	50.21%
American Journal of Obstetrics and Gynecology	76	50.94%
Plos One	73	51.64%
World Journal of Surgery	69	52.30%
Journal of Pediatric Gastroenterology and Nutrition	67	52.94%

published was 145 ± 90. Each surgeon was cited 3635 ± 413 times. The most frequent journals in which these authors published were extracted, along with the number of publications in each of those journals (Table 2). The top five journals in which the authors published were *Journal of Pediatric Surgery*, *Journal of Surgical Research*, *Pediatric Surgery International*, *Seminars in Pediatric Surgery*, and *Annals of Surgery*.

Application of Bradford's law of scattering to pediatric surgery

Within their published articles, each surgeon cited 2891 ± 176 articles (199507 in total). We analyzed 58,310 references from the top 20 journals in which pediatric surgeons published, accounting for 52.94% of the total number of referenced articles (Table 3). Because the value of p (number of zones) has not yet been established for pediatric surgery, values of p = 3-10 were applied to determine the best result. We found that values of p = 3-5 produced valid results (nonzero values of the Bradford multiplier k, zones with non-zero numbers of journals). For all values of p = 3-5, a single core journal was identified; *Journal of Pediatric Surgery* (18,790 articles) (Fig. 2A, C, E). The verbal formulation of Bradford's Law and the observed distributions were plotted, and Pearson's correlation was used to identify the ideal value of *P* when comparing observed versus theoretical distributions (Fig. 2B, D, F). This identified *P* = 3 zones as ideal for pediatric surgery. The second zone was made up of 13 journals with 19,564 articles and 37,438 citations (predicted 37,580). This zone included *Pediatrics*, *Annals of Surgery*, *New England Journal of Medicine*, *Pediatric Surgery International*, *Journal of Pediatrics*, *Journal of Trauma*, *Journal of Clinical Oncology*, *Journal of Biological Chemistry*, *Proceedings of the National Academy of Sciences*, *Cancer*, *American Journal of Obstetrics and Gynecology*, *Archives of Surgery*, and *Surgery*. (Fig. 2A).

Discussion

Pediatric surgeons publish in a variety of surgical, medical, and other journals, making it difficult to stay up to date with current literature. Until now, there has not been a study to identify the core journals of pediatric surgery. The top journals that pediatric surgeons publish in, based on number of articles, are the following in descending order: *Journal of Pediatric Surgery*, *Journal of Surgical Research*, *Pediatric Surgery International*, *Seminars in Pediatric Surgery*, and *Annals of Surgery*. Thus, most pediatric surgery publications are in surgical journals, specifically in pediatric surgery journals. A similar pattern was found when examining the journals from which pediatric surgeons draw their references, resulting in the identification of the *Journal of Pediatric Surgery* as the core journal. However, the middle zone consists of journals whose concentration range from general medicine, pediatrics, surgery, to other specialties like trauma, biochemistry, and oncology. This is likely reflection of the broad range of diseases that pediatric surgeons treat and study.

There are several important considerations to the use of Bradford's Law and its methods. First, Bradford's Law can only

Table 3 – Top 20 journals from which pediatric surgeons cite in their publications.

Journal	Number of citations	Cumulative number of citations	Percentage of citations	Cumulative % of citations
Journal of Pediatric Surgery	18,790	18,790	32.22%	32.22%
Pediatrics	2892	21,682	4.96%	37.18%
Annals of Surgery	2790	24,472	4.78%	41.97%
New England Journal of Medicine	1845	26,317	3.16%	45.13%
Pediatric Surgery International	1507	27,824	2.58%	47.72%
Journal of Pediatrics	1479	29,303	2.54%	50.25%
Journal of Trauma Injury Infection and Critical Care	1412	30,715	2.42%	52.68%
Journal of Clinical Oncology	1323	32,038	2.27%	54.94%
Journal of Biological Chemistry	1302	33,340	2.23%	57.18%
Proceedings of The National Academy of Sciences of The United States of America	1112	34,452	1.91%	59.08%
Cancer	1042	35,494	1.79%	60.87%
American Journal of Obstetrics and Gynecology	1006	36,500	1.73%	62.60%
Archives of Surgery	938	37,438	1.61%	64.21%
Surgery	916	38,354	1.57%	65.78%
Gastroenterology	892	39,246	1.53%	67.31%
American Journal of Surgery	880	40,126	1.51%	68.81%
Ultrasound in Obstetrics and Gynecology	711	40,837	1.22%	70.03%
Cancer Research	699	41,536	1.20%	71.23%
Blood	652	42,188	1.12%	72.35%
Nature	598	42,786	1.03%	73.38%

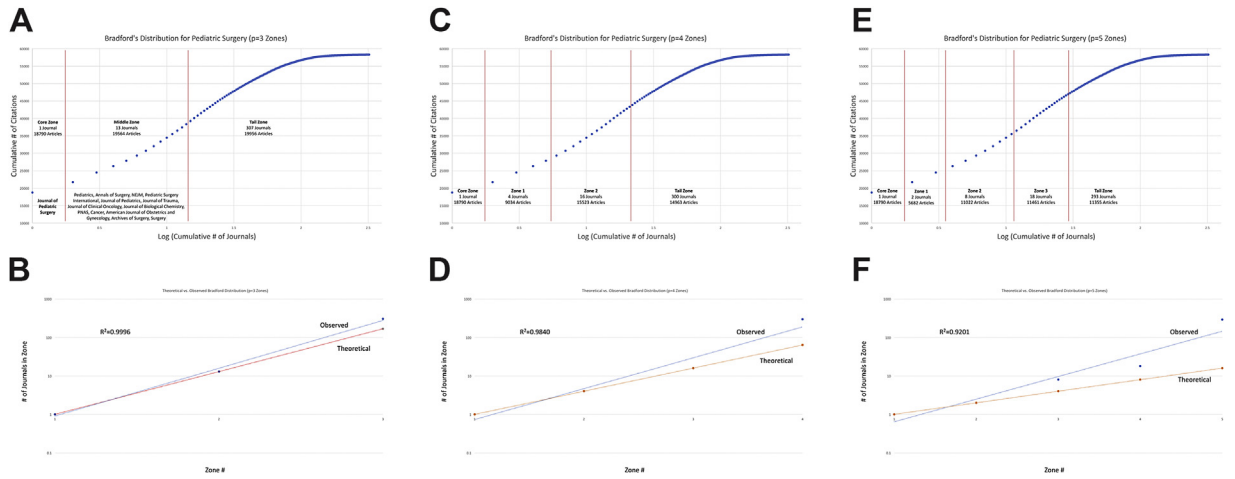

Fig. 2 – Bradford's distributions for values of p = 3-5. (A) Bradford's distribution for P = 3 zones. (B) Correlation between theoretical and observed distribution for P = 3 (R^2 = 0.9996). (C) Bradford's distribution for P = 4 zones. (D) Correlation between theoretical and observed distribution for P = 3 (R^2 = 0.9840). (E) Bradford's distribution for P = 5 zones. (F) Correlation between theoretical and observed distribution for P = 3 (R^2 = 0.9201).

work for a particular subject if it satisfies the following three conditions: a clear presentation of subjects, a large list of journals pertaining to the subject, and a definite time span for analysis of the journal articles.[11] In the case of this study, all three requirements have been met. The second limitation relates to generalizability of Bradford's Law. Bradford's law of scattering has been used to determine the core journals in many fields. However, there are disadvantages to this broad application. In a publication by Nicolaisen and Hjørland[12] in 2005, the authors proposed that Bradford's Law is not as neutral as it is perceived to be in that the subject of an article may be ambiguous. This issue is encountered when the core journals are selected by the keywords or concepts, rather than by subjects, which consequently influences the results by grouping articles that may not be truly related. In other words, "an adequate indexing of documents is as relevant for providing Bradford distribution as it is for providing relevant documents to users". In addition, the selection of core journals risks creating a scientific environment wherein only the widely accepted views and approaches are considered, whereas the less favored views cannot easily be found. This may prevent readers from forming an objective opinion on the topic at hand.

With respect to limitations of this particular study, there are a few to consider. First, there are limitations related to the database we created. This study was based on work completed earlier this year thereby only reflecting the h-indices collected during the period between January through April of 2017.[10] In addition, when collecting the citations and the journals in which the top surgeons published, articles that were published before 1970 and after August 2017 were not included as they had not yet been updated within the Scopus database. Scopus also listed some publications under the incorrect author because of the similarity in author names. As there were only a handful of instances, it was not considered significant enough to alter the results. It is worth noting that the quality of a publication (e.g., case report versus randomized clinical trial) is not taken into consideration when calculating h-index, so that an author with highly cited case reports may have a comparable h-index to an author with highly cited clinical trials. Finally, this study only examines the journals in which pediatric surgeons at US pediatric surgery fellowship training programs publish. The results may differ if academic surgeons outside of fellowship training programs or from the global academic pediatric surgery community were included and future research can be done to establish the top journals around the world.

The results of this study have implications for trainees and practicing pediatric surgeons alike. The list of core journals can guide surgeons in training to the most high-yield journals and provide a starting point for investigating a particular subject with pediatric surgery. Similarly, fully trained surgeons can maintain their fund of knowledge by having the ability to turn to a handful of journals to find the latest developments. Surgeon-scientists with expertise or interest in pediatric surgery may find it easier to reach their target audience by focusing their publishing efforts on the core journals. Regardless of one's educational goals, this study provides guidance for the optimal starting point when reading current pediatric surgery literature.

Conclusions

This study is the first to apply Bradford's law of scattering to the field of pediatric surgery to establish a set of core journals. This information will be useful to guide residents, fellows, and attending surgeons to specific journals, facilitating efforts to stay current in a rapidly evolving field. In addition, academic pediatric surgeon-scholars can target their own work to these journals to efficiently disseminate their findings.

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