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Predictors of citations in the urological literature

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To assess the factors associated with increased citation rates in the urological literature by reviewing articles published in the four major urological journals to help authors improve the impact of their work. A random sample of 200 original research articles published between January and June 2004 was analysed from *The Journal of Urology, Urology, European Urology* and *BJU International*. Study information was abstracted by two independent reviewers and citation counts within 4 years of publication were collected using Web of Science™. Study characteristics and citation rates were analysed using median and interquartile ranges (IQRs), and logistic regression analysis was used to evaluate which factors predicted greater citation rates. The overall median number of citations per published article was 6.0 (IQR 3–12). After univariate analysis, we found that study design, study topic, continent of origin and sample size were associated with greater median citation rates. In a multivariate linear regression model, study design and study topic (oncology) predicted increased citation rates.Randomized controlled trials were cited a median of 13.5 times and were the strongest predictor of citation rates with an odds ratio of 115.5 (95% confidence interval 9.4–1419.6). Citation rates are associated with study design and study topic in the urological literature. Authors may improve the impact of their work by designing clinical studies with greater methodological safeguards against bias.

What's known on the subject? and What does the study add?
Citation rates have been previously studied in the general medical literature and in a few subspecialties. The results of these studies have differed showing an association with citation rates and multiple study characteristics that include the design of the study, study topic, industry funding, the number of authors and institutions, newsworthiness, sample size, and journal prestige.

Correlates with citation rates have never been studied within the field of urology, but are important as urology is a unique surgical discipline with complex disease processes and rapidly changing technology. Our study is the first to evaluate the factors associated with increased citation rates in the urological literature and will assist authors in improving the impact of their work in urology.

KEYWORDS

citation analysis, citation, self-citation, journal impact factor, urology, bibliometrics

INTRODUCTION

Peer-reviewed journals are used to disseminate important research findings to the scientific community. In order to achieve the greatest possible impact, investigators aim to publish their work in top tier journals. One measure of impact is the number of times an article is cited after publication. A higher number of citations is viewed as an indicator of the importance of the research. Having a research article cited by multiple sources facilitates the dissemination of its message among the medical community and encourages its application to patient care. The rate of citation is also a surrogate marker for the impact of the journal publishing the article. This 'impact factor' is calculated as the mean number of citations per year for all articles published in a particular journal in the previous 2 years [1] and is used to compare impact between scientific journals.

Previous efforts to describe factors associated with higher citation rates have been performed within the medical literature [2–6]. While only one of these studies was performed within a surgical discipline, each study found a diverse correlation between study characteristics and increased citation rates. These include an association between increased rates of citation and study design, study topic, the presence of industry funding, the number of authors and institutions, newsworthiness score, sample size and journal prestige. Surgical research brings with it a unique set of challenges including a rapid influx of new technology, issues with patient selection and human bias. Urology, in particular, is a field ripe for clinical and scientific research with its complex disease processes and rapidly changing technology. The purpose of our study was to evaluate the factors associated with increased citation rates in the urological literature to assist authors in improving the impact of their work in urology.

MATERIALS AND METHODS

SELECTION OF JOURNALS AND ARTICLES

We selected the four general urology journals with the highest impact factor in the field for review, namely *The Journal of Urology, Urology, European Urology* and *BJU*

TABLE 1 Sample characteristics

Characteristic	*n* (%)
Study design	
Randomized controlled trial	13 (6.5)
Prospective observational	66 (33)
Retrospective observational	98 (49)
Case report/series	23 (11.5)
Study type	
Oncology	106 (53.0)
Stones/Endourology	11 (5.5)
Pediatrics	22 (11.0)
Voiding dysfunction	29 (14.5)
Trauma/Reconstruction	10 (5.0)
Infection/Inflammation	9 (4.5)
Infertility/Erectile dysfunction	12 (6.0)
Other	1 (0.5)
Continent	
North America	64 (32.0)
Europe	92 (46.0)
Asia	35 (17.5)
Other	9 (4.5)
Sample size	
1–20	48 (24.0)
21–100	82 (41.0)
>100	70 (35.0)
Industry funding	
Yes	34 (17.0)
No	166 (83.0)
Number of institutions	
1	109 (54.5)
>1	91 (45.5)
Number of authors	
1–3	48 (24.0)
4–6	100 (50.0)
>6	51 (25.5)

International. We included original scientific articles published in a 6-month time period from 1 January 2004 to 30 June 2004 in the study. We excluded narrative review articles, editorials, letters and basic science research studies, which yielded a total of 1293 eligible studies. We imported all scientific articles into EndNote™ thereby assigning them a unique reference number. We then used the random number generator included in Microsoft Excel 2003™ that has been approved for this purpose by the National Institute of Standards and Technology to select 50 studies from each journal for a total of 200 articles included in the analysis [7].

DATA ABSTRACTION

We evaluated the random sample of articles using a standardized evaluation form that included variables that have been previously reported to predict rates of citations in similar studies outside of the urological literature [2–6]. These were study design (systematic reviews, randomized controlled trials, prospective observational studies, retrospective observational studies, case reports/series), number of authors (1–3, 4–6, >6), number of institutions (1, >1), continent of origin (North America, Europe, Asia or other), source of funding (industry-funded or not), and study topic (Table 1). For the purpose of this comparison, studies with ≤20 patients were categorized as case reports/series. Both comparative and non-comparative studies with >20 patients were categorized as retrospective, unless explicitly categorized as prospective by the authors. Study topic was collapsed into two categories: oncology and non-oncology. The data abstraction form was pilot-tested in two separate sets of five articles. One reviewer (C.D.B.) abstracted data from all 200 articles. To assess for accuracy, a second reviewer (D.L.W.) independently abstracted data from a 10-% random sample of the selected articles.

The primary outcome measure was citation rate, defined as the number of citations received within 4 years of publication. The secondary endpoint was the number of self-citations. Citation data was collected using the Institute for Scientific Information Web of Science database (http://isiknowledge.com, with institutional access). Using this database, a search for all 200 abstracted articles using the first author's last name was performed to evaluate the number of times they were cited by other published studies. Thereafter, the contribution of self-citations to the overall citation rate of a particular article was analysed. A self-citation was defined as a citation by any co-author of the original article. Self-citation rates were determined by searching each citing article generated by the Web of Science database for all author names from the original article. The predefined study period of 48 months was calculated from the date of first publication (online or print) of the individual study. One member (C.D.B.) of the investigative team performed the analysis of the overall citation and self-citation rates and a second reviewer (D.L.W.) confirmed accuracy in a 10-% random sample.

STATISTICAL ANALYSIS

We performed descriptive analyses and statistical hypothesis-testing using SPSS Version 18.0. We analysed categorical variables using proportions and continuous variables using the median and interquartile range (IQR). We further performed non-parametric independent samples median testing and binary logistic regression analysis to assess for associations between predictor and outcome variables. The logistic regression analysis evaluated factors predicting citation rates greater than the median number of citations. A two-sided α value of 0.05 was used to indicate statistical significance without formal adjustment for multiple comparisons.

RESULTS

Table 1 summarizes the study characteristics of the 200 articles in the study sample. Oncology was the single most common study topic ($n = 106$; 53.0%). The majority of studies ($n = 121$; 60.5%) were retrospective and most studies originated from either Europe ($n = 92$; 46.0%) or North America ($n = 64$; 32.0%). Approximately half the studies included authors from more than one institution ($n = 91$; 45.5%). The median number of authors was 5 (IQR 4–7) and the median sample size was 59.5 (IQR 21.8–177.3).

Citation analysis identified a total of 2108 citations within 48 months of publication. The relative citation rates at 12, 24, 36 and 48 months were 12.6, 41.1, 70.2 and 100.0%, respectively. The median number of citations per published article was 6 (IQR 3–12). The median citation rates for *The Journal of Urology, European Urology, Urology* and *BJU International* were 8, 8, 6 and 5, respectively ($P = 0.113$; Table 2). Thirty-seven percent of the citations occurred in non-urological journals.

Table 2 summarizes the citation rates analysis according to study characteristics. In a univariate analysis, study design, study topic, continent of origin and sample size were associated with overall citation rates. Specifically, randomized controlled trials, oncology-related studies, studies originating from North America and studies that enrolled >100 patients were associated with higher citation rates. Other variables such as journal of publication and reported funding source did not meet statistical significance. In a multivariate logistic regression model that included all predictor variables, study

design and study topic (oncology) were predictive of increased citation rates (Table 3). The odds ratio was the largest for randomized controlled trials at 115.5 (95% CI: 9.4–1419.6).

Self-citations were not a major contribution to the overall citation rates with the median number of self-citations ≤2. An association with self-citation rates was noted only for study design, number of institutions and sample size, but not journal of publication or funding source (Table 2). The low event rate precluded further interpretation of a multivariate analysis.

TABLE 2 Median citation and self-citation rates by study characteristics

Variables	Median citations (IQR)	*P*	Median self-citations (IQR)	*P*
Study Design				
RCT	13.5 (8.25–36.75)	<0.001	2 (0.75–5.75)	<0.001
Prospective	6 (5–12)		1 (0–2)	
Retrospective	7 (3.5–12)		1 (0–2)	
Case Report/Series	1 (0–2)		0 (0–0)	
Journal				
The Journal of Urology	8 (5–16.25)	0.113	1 (0–3)	0.207
European Urology	8 (3–12)		0 (0–2)	
Urology	6 (3–12.25)		0 (0–2)	
BJU International	5 (2–9)		0 (0–1)	
Study Topic				
Oncology	8 (3–14.25)	0.016	1 (0–2)	0.22
Non-oncology	5 (2–9)		0 (0–1.25)	
Continent				
North America	8 (4.25–14)	0.023	1 (0–2)	0.740
Europe	7.5 (3–13)		1 (0–2)	
Asia	3 (2–7)		0 (0–1)	
Other	4 (2.5–8.5)		0 (0–1)	
Number of Institutions				
1	5 (2–11)	0.179	0 (0–2)	0.017
>1	8 (4–13)		1 (0–2)	
Number of Authors				
1–3	7 (3–10)	0.367	0 (0–1.75)	0.247
4–6	6 (2.25–12)		0 (0–2)	
>6	8 (4–15)		1 (0–3)	
Sample Size				
1–20	3 (1–7.75)	0.002	0 (0–1)	0.012
21–100	6.5 (4–12)		1 (0–2)	
>100	8 (5–14.25)		1 (0–3.25)	
Industry Funding				
Yes	8 (5–17)	0.399	2 (0–4)	0.065
No	8 (8–8)		0 (0–0)	
N/A	6 (3–11)		0 (0–2)	

RCT, randomized controlled trial.

Variable	Odds ratio (95% CI)	*P*
Study design		
Randomized controlled trial	115.5 (9.4–1419.6)	<0.001
Prospective observational	19.3 (2.2–168.0)	0.007
Retrospective observational	24.6 (3.2–187.6)	0.002
Case report/series	Referent	
Study topic		
Oncology	2.5 (1.4–4.7)	0.004
Non-oncology	Referent	

TABLE 3 Independent predictors of median citations >6 after binary logistic regression analysis

DISCUSSION

In this first study of its kind to address the urological literature, we analysed the association between study characteristics and subsequent citation rates. The principal finding of our investigation was the strong association of study design with subsequent rates of citation. The median number of citations after publication of a randomized controlled trial in one of four major urological journals was 13.5 vs. 1 for a case report/series. This association was preserved when analysed in a multivariate analysis in the presence of other co-variables and possessed a stronger association than that of median number of citations with other study designs or study topic. The recent trend of major journals to no longer publish case reports reflects this observation. These findings are important in light of the relevance that citations have in the research community as a measure of the impact of a researcher's efforts. Additionally, these findings suggest that study designs with stronger methodological safeguards against bias, such as randomized controlled trials, are recognized as providing higher quality evidence in the literature. Studies of higher methodological quality result in significantly more citations, thereby potentially off-setting some of the increased effort and resource utilization associated with their planning, execution and analysis. From the perspective of a new urological investigator seeking to establish himself in a given field of research, it may therefore be worthwhile to focus efforts on leading a few well designed, controlled prospective studies that will advance the field rather than spreading his efforts across multiple retrospective studies that are less likely to be cited. This argument from the investigator perspective is well aligned with other studies that have emphasized the urgent need to raise the quality of evidence of studies provided by the urological literature to better support evidence-based clinical practice [8–10].

The findings of the present study are concordant with observations made by Bhandari *et al.* [2] when analysing the orthopaedic literature, the only other study investigating the surgical literature that we

were able to identify. These authors found that systematic reviews/meta-analyses and randomized controlled trials were most likely to be cited in general and in the medical literature outside the specialty of orthopaedics [2]. In a citation analysis of the general medical literature, Patsopoulos *et al.* [3] made similar observations with systematic reviews/meta-analyses and randomized controlled trials being the most cited studies. Of note, no systematic reviews/meta-analyses were encountered in our study, thereby precluding analysis of the associated citation rates.

Other studies assessing citation rates have shown correlation with study factors other than study design. Callaham *et al.* [4] reviewed citation rates in the emergency medicine literature and found that study design and methodology did not correlate with the frequency of citation rates. Rather, the prestige of the publishing journal was more important than other variables [4]. In our analysis, journal of publication was not a predictor of citation rates when we adjusted for other variables including study design. Kulkarni *et al.* [5] showed that trials with a large sample size, group authorship, industry funding, or in the fields of oncology or cardiology were associated with greater subsequent citations. Kulkarni *et al.* further discovered that studies with an industry-favouring result were associated with the largest increase in annual citation rate, while study design failed to correlate with citation rates [5]. All of these variables were incorporated into our study, yet only study design and study topic (oncology) were associated with increased citation rates in a multivariate analysis. Industry funding, which was reported in 17% of included studies, was also not associated with increased citation rates in our study. Figg *et al.* [6] found a correlation between the number of authors and the number of times an article was cited, and concluded that collaboration may yield a superior product that results in higher impact. However, Figg *et al.* did not incorporate study design or methodology into their analysis [6].

For a better understanding of our study's implications, its strengths and weaknesses deserve consideration. First, our study analyses a random sample of studies published in 2004 that provide a minimum of 4 years of follow-up for a citation analysis. What is uncertain, however, is to what extent the results can be generalized to contemporary citation practices. One observation likely to change if our study were to be repeated in the future would be the number of systematic reviews available for citation analysis. A recent study by MacDonald *et al.* [10] has shown an exponential increase in the number of systematic reviews published annually, with a consistent trend across the four journals included in our analysis. The authors surmised that the underlying reasons included an increased recognition of these studies' importance in the evidence-based practice of urology, but also the reported positive impact these studies have on subsequent citations, as reflected in the journals' respective impact factors. Unfortunately, our study was unable to investigate the citation rates for this type of study design.

Second, study quality hinges on more than study design alone and efforts to enhance the methodological quality of studies may also affect subsequent citation rates, for example by incorporating the formal endorsement of guidelines of transparent reporting as promoted by the EQUATOR working group [11]. Such efforts since 2004, including the endorsement of the CONSORT criteria [12] by *BJU International* and *European Urology*, would not be reflected in our study. Furthermore, we recognize that citation rate and journal impact factor do not necessarily correlate with scientific quality or academic success [13–16]. Meanwhile, the strengths of our study include its extended follow-up, inclusion of multiple predictor variables previously reported to be associated with citation rates and the high degree of interobserver agreement found with verification of the data abstraction accuracy by a second independent investigator.

While the use of citation rates to calculate scientific quality or the journal impact factor is not without issues, it represents a widely accepted and used surrogate marker of research success and academic impact for individual investigators, journals and institutions. The implication of our study is that editors, funding agencies and research mentors should encourage new investigators to produce studies with strong methodological safeguards against bias as these are likely to have higher impact and be cited more frequently. Furthermore, journal editors may consider citation potential when deciding which manuscripts to accept in order to maintain or increase the overall impact of their journal.

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CONFLICT OF INTEREST

None declared.

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Abbreviation: **IQR**, interquartile range.