Randomized Trials Published in the *Journal of Dental Research* are Cited More Often Compared with Those in Other Top-Tier Non–Specialty-Specific Dental Journals

Veerasathpurush Allareddy, BDS, MBA, MHA, PhD[1], Andrea Shah, BS[2], Chin-Yu Lin, DDS, MS, MSD, PhD[3], Satheesh Elangovan, BDS, DSc[4], Min Kyeong Lee, BS[2], Kimberly Chung[5], Sivabalan Vasudavan, BDSc, MDSc, MPH[6], and Nadeem Y. Karimbux, DMD, MMSc[7]

[1]Orthodontics Resident, Department of Developmental Biology, Harvard School of Dental Medicine
[2]DMD student, Harvard School of Dental Medicine
[3]Orthodontics Director, Department of Developmental Biology, Harvard School of Dental Medicine
[4]Periodontics Resident, Department of Oral Medicine, Infection, and Immunity, Harvard School of Dental Medicine
[5]Undergraduate student, University of California – San Diego
[6]Craniofacial Fellow, Department of Developmental Biology, Harvard School of Dental Medicine and Children's Hospital of Boston
[7]Associate Professor, Department of Oral Medicine, Infection, and Immunity, and Assistant Dean for Dental Education, Harvard School of Dental Medicine

Background and Aim: Randomized controlled trials (RCTs) are viewed as the gold standard for clinical research. Oftentimes the citation counts serve as an important measure for assessing the significance of an RCT to promote the dissemination of science. This study attempts to identify the factors associated with the number of times RCTs are cited within the first 24 months since publication. **Materials and Methods:** RCTs published between January 1, 2002, and November 30, 2006, in 4 journals (*Journal of Dental Research*, *European Journal of Oral Sciences*, *Journal of Dentistry*, and *Clinical Oral Investigations*) were selected for analysis. Citation counts of RCTs in the first 24 months since publication was the outcome variable. The independent variables included journal of publication, geographic region of origin of study, number of authors, financial support, number of references, presentation of a statistically significant result, and if the study was conducted on animals. Bivariate associations between the outcome and independent variables were examined by Kruskal-Wallis test, Mann-Whitney *U* test, and Spearman rank correlations where appropriate. A multivariable negative binomial regression model was also built to examine the association. **Results:** A total of 163 RCTs were selected for analysis. The mean citation count for the first 24 months count was

Corresponding Author: Dr. Veerasathpurush Allareddy, BDS, MBA, MHA, PhD, Department of Developmental Biology, Harvard School of Dental Medicine, Tel: – 216-571-1009; E-mail: VA15@hsdm.harvard.edu.
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2.61. Close to 20% of RCTs were not cited even once in this observation period. RCTs published in the highest impact factor journal (*Journal of Dental Research*) tended to be cited most often ($P < .05$). **Conclusion:** Based on our initial analysis of 4 journals, publishing randomized trials in high-impact journals will likely provide better dissemination of research findings.

Keywords: Citations, Randomized controlled trials, Impact factor, Study design.

BACKGROUND

Randomized controlled trials (RCTs) are viewed as the gold standard for clinical research based on the relative reliability of their study design.[1-3] They are designed with a random and blinded allocation of different interventions to study subjects, where the sample size is sufficient to offset the effects of known and unknown confounding factors.[1-4] RCTs tend to be carried out in multiple centers and well-designed studies are expected to be both reliable and valid. The results of RCTs are often used as the basis for important clinical decision-making purposes.[4]

Publishing a scientifically valid clinical research article is a vital step in the dissemination of research. However, the number of times an article is cited by other researchers serves as an important indicator for active scientific debate and, as a result, an equally important step in the advancement of science.[5-7] Oftentimes, the citation count serves as an important measure for assessing the significance of a published article to promote the dissemination of science. The medical literature suggests that the citation count increases through publication in high-impact journals[5,8]; however, there are no studies in the dental literature that determine factors associated with increased citation counts of RCTs.

The specific aim of this study was to examine the first 24-month citation counts of RCTs that were published over a 5-year period between 2002 and 2006. This study attempted to identify factors associated with the number of times RCTs are cited within the first 24 months since publication.

MATERIALS AND METHODS

Database and Article Selection

The PubMed database was used for this study. A total of 51 journals related to dentistry are indexed by the ISI Web of Science Journal Citation Reports.[9] All these journals have an impact factor (ranging from a high of 3.581 for *Periodontology 2000* to 0.500 for *Australian Dental Journal*).[9] We ranked all 51 journals based on the impact factor. The first 20 ranked journals were selected. From these, only the top 4 journals that were not specialty specific or country specific and published on a wide range of topics were selected. We did not include specialty-specific journals such as *Periodontology 2000, Journal of Endodontics, Dental Materials, Journal of Clinical Periodontology*, and so forth, which had higher impact factors than 3 of the journals we selected (*Journal of Dentistry, Clinical Oral Investigations,* and *European Journal of Oral Sciences*) because we did not want specialty-specific effects to bias our results. The journals selected included *Journal of Dental Research, European Journal of Oral Sciences, Journal of Dentistry*, and *Clinical Oral Investigations*. In 2007, the impact factors for these journals were 3.496, 2.071, 1.995, and 1.956, respectively.[10] RCTs, as indexed by PubMed, published between January 1, 2002, and November 30, 2006, in these 4 journals were used for analysis. In the initial PubMed search, a total of 197 published RCTs were identified. Of these, 8 from the *Journal of Dentistry* and 6 from *Clinical Oral Investigations* were published in hard-copy format after November 30, 2006, and hence were not included in the current study. One study, from the *Journal of Dental Research*, evaluated the statistical approaches to conducting an RCT and, consequently, was omitted from our study. Nineteen RCTs from *Clinical Oral Investigations* published in 2002 did not have a citation count available from the Web of Science and, as a result, were not included in the current study. Our final sample consisted of 163 published RCTs after exclusions.

Outcome Variable

The number of times an article was cited in the first 24 months since its publication was the outcome variable of interest for this study. Information regarding the number of times an article was cited was obtained from the Web of Science – Science Citation Index.[10] Although this service provides citation counts and also the reference of the citing article, it does not provide any information on the quality of the original study or of the citing article. Furthermore, this service includes only articles that are published in journals and does not include articles that are published online, in newsletters, or cited in thesis/dissertation works. Consequently, the citation counts of articles tend to be underestimated.

Independent variables

The independent variables of interest in this study included the journal in which the study was published, geographic area of the study origin, number of authors, type of financial support to conduct the study, number of references used by the study, statistically significant results of

the study, and if the study was conducted on animals. This information was extracted from the PubMed database and by reviewing each article. As previously mentioned, the published RCTs were obtained from 4 journals: *Journal of Dental Research*, *European Journal of Oral Sciences*, *Journal of Dentistry*, and *Clinical Oral Investigations*. To determine the geographic region of the RCT, the country of study origin, as indexed in the PubMed database, was used. Each article was broadly categorized based on its continent of origin (North America, South America, Europe, Asia, Africa, and Oceania). Information regarding funding source of the RCT was obtained by querying the PubMed database. The articles were classified as being at least partially supported by the US government, exclusively non–US government supported (includes both foreign governments and industry funding), and nonfunded studies. Information on study subjects (animals or humans/human specimens) was obtained from the PubMed database. The primary hypothesis of each article was reviewed and the results were examined for statistical significance. The number of authors and references used in the articles were obtained from the article and were used as continuous variables in the bivariate and multivariable analyses.

Analytical Approach

Simple descriptive statistics including mean, standard deviation, median, range, and frequency distributions were used to describe the outcome variable (number of citations) and all independent variables. A 1-sample Kolmogorov-Smirnov test was used to examine the normality of distribution of the outcome data (number of citations). The Kruskal-Wallis test was used to examine the association between the number of citations and publishing journal. Multiple post hoc tests using the Mann-Whitney *U* test were used to examine differences among different journals. Multiple testing introduces the possibility of Type-1 errors. To minimize Type-1 errors, Bonferroni corrections were used. Because there were 4 different study design groups, a total of 6 post hoc comparisons would have to be performed to examine differences among all groups. To minimize Type-1 errors, a *P* value of less than .008 was deemed to be statistically significant (2-tailed tests) for the post hoc comparisons. The association between the number of citations and continent of origin was also examined by the Kruskal-Wallis test. Similarly, the association between the number of citations and funding source was also examined. Multiple post hoc testing was conducted to find differences in citations among groups. Because there were 3 groups and 3 pairwise post hoc comparisons were made, a *P* value of less than .0167 was deemed to be statistically significant. Associations between the number of citations and the number of authors and number of references were examined using Spearman's rho correlation coefficients. A multivariable regression model was developed to examine the association between the outcome variable and the independent variables. We modeled the number of citations as a continuous variable. Because the number of citations is count data and the data were widely dispersed, we used a multivariable model in which a negative binomial regression approach was used. All statistical tests were 2-sided and a *P* value of less than .05 was deemed to be statistically significant (except where post hoc multiple comparisons were made, as mentioned earlier). Statistical analyses were conducted by SPSS version 16.0 (SPSS, Statistical Package for Social Sciences, Chicago, Illinois) and STATA version 8.0 (Stata; College Town, Texas).

RESULTS

A total of 163 articles were selected for analysis, most of which were published in the *Journal of Dentistry*. Among the different geographic regions, Europe accounted for the most articles. A vast majority of the articles presented a statistically significant result. The descriptive statistics of the selected articles are summarized in Tables 1 and 2. The outcome data were not normally distributed ($P < .001$) and as mentioned in the Materials and Methods section, nonparametric tests were used to examine the association between the outcome and independent variables of interest.

Close to 20% of the published RCTs that were included in our study were not cited at least once in the first 24 months since their publication. The average number of citations during the observation period (24 months since publication) was 2.61 (SD of 3.11 and range of 0 to 24) (Table 2). Articles published in the *Journal of Dental Research* had the highest mean number of citations. The studies funded at least in part by the US government tended to be cited more often compared with those funded by non–US government sources or nonfunded studies. RCTs that presented a statistically significant result also had a higher mean number of citations as compared with those that did not present a statistically significant result (Table 3).

The *P* values from the Kruskal-Wallis test examining the association between the number of citations and publishing journal are summarized in Table 4. The results from these analyses suggest that there is a statistically significant difference in the number of citations among journals. Pairwise multiple post hoc comparisons revealed that RCTs published in the *Journal of Dental Research* tended to be cited more often than those published in the *Journal of Dentistry* ($P < .0001$). Results from the multivariable analyses (Table 5) further confirm that RCTs published in the *Journal of Dental Research* were associated with a higher number of citations compared with RCTs published in the *Journal of Dentistry* ($P = .001$) and the *European Journal of Oral Sciences* ($P = .018$), even after adjusting for the effects of other independent variables. Results of the bivariate analysis examining the association between citation

TABLE 1. Characteristics of randomized controlled trials selected for analysis

Characteristic	Frequency (%)
Journal	
Clinical Oral Investigations (IF = 1.956)	18 (11)
European Journal of Oral Sciences (IF = 2.071)	23 (14.1)
Journal of Dentistry (IF = 1.995)	73 (44.8)
Journal of Dental Research (IF = 3.496)	49 (30.1)
Continent	
North America	23 (14.1)
South America	22 (13.5)
Europe	94 (57.7)
Asia	21 (12.9)
Africa	0
Oceania	3 (1.8)
Funding source	
US government	10 (6.1)
Exclusively non–US government	90 (55.2)
Not funded	63 (38.7)
Subjects	
Animals	7 (4.3)
Humans (including human subjects, specimens, and materials)	156 (95.7)
Significant result in the study	
Yes	137 (84)
No	26 (16)

IF, impact factor.

counts and funding source are summarized in Table 6. Post hoc comparisons using the Mann-Whitney *U* test followed by Bonferroni corrections revealed that studies funded at least in part by the US government were associated with a higher number of citations compared with those funded by non–US government sources ($P = .004$) or nonfunded studies ($P = .001$). Funding source was not significantly associated with a higher number of citations after adjusting for the effects of other independent variables. An increase in the number of authors ($P = .017$) and number of references ($P = .001$) was associated with an increase in the number of citations (Table 5).

DISCUSSION

In summary, although RCTs are considered to be the gold standard of clinical research evidence, the results from our review show that close to 20% of the RCTs from our sample were not cited at least once during the first 24 months since their publication. RCTs published in the *Journal of Dental Research* tend to be cited more often as compared with RCTs published in the *Journal of Dentistry* and the *European Journal of Oral Sciences*, even after adjusting for several confounding factors.

Our study results are consistent with previous studies examining the association between a journal's impact factor and its articles' citation counts.[5,8] Several studies have shown that the impact factor of a journal is one of the strongest predictors of citation counts.[5,8] Filion and Pless[5] examined citation counts of articles published between 1998 and 2004 focusing on child injury prevention and coronary artery disease. They examined if author, country, journal, or topic are associated with the number of times epidemiological studies get cited. They found that the publishing journal and the country of study origin are the factors most significantly associated with citation counts.[5] Similar to our study, Filion and Pless[5] found that highly cited articles are predominantly published in high-impact, high-circulation journals. Callaham and colleagues,[8] in a separate study, examined citation counts of 204 published articles focusing on emergency medicine and found that the impact factor of the original publishing journal is the strongest predictor of citations.

In contrast to the study by Filion and Pless,[5] we did not examine the association between country and citation counts. As alluded to earlier, there were 30 different countries from which the RCTs in our study originated. Thus, including all countries in the multivariable model would not be statistically feasible. However, we grouped the articles based on the continent from which they originated and found that the geographic origin of a study was not significantly associated with citation counts.

The primary observation period in our study was the first 24 months since publication of the RCT. We chose a 24-month observation period because the impact factors for journals are calculated based on this time period, thus allowing for normalization of the exposure period for all articles in our study.[10] One may argue that this observation period is short and that certain articles tend to have increased citations after 2 years

TABLE 2. Characteristics of randomized controlled trials selected for analysis

Characteristic	Mean	SD	Minimum	25th percentile	Median	75th percentile	Maximum
No. of citations	2.61	3.11	0	1	2	4	24
No. of authors	4.80	1.82	1	4	5	6	14
No. of references	27.79	10.92	7	20	27	34	65

TABLE 3. Citations by journal, continent, funding source, subjects, significance of study result

Characteristic	Mean	SD	Minimum	25th percentile	Median	75th percentile	Maximum
Journal							
Clinical Oral Investigations	2.56	1.89	0	1	3	4	7
European Journal of Oral Sciences	2.13	2.03	0	1	2	3	9
Journal of Dentistry	1.84	2.24	0	0	1	2	13
Journal of Dental Research	4	4.35	0	1	3	6	24
Continent							
North America	3.39	3.92	0	1	2	4	19
South America	1.82	2.13	0	0.75	1	2.25	8
Europe	2.73	3.27	0	1	2	4	24
Asia	1.86	2.01	0	0	1	3	8
Oceania	3.67	2.52	1	1	4	6	6
Funding source							
US government	6	5.08	1	2.75	5	7.25	19
Exclusively Non–US government	2.66	3.19	0	1	2	4	24
Not funded	2	2.15	0	1	1	3	13
Subjects							
Animals	2.71	2.69	0	1	2	4	8
Humans	2.60	3.13	0	1	2	4	24
Significant result in the study							
Yes	2.75	3.3	0	1	2	4	24
No	1.85	1.62	0	0.75	1.5	3	6

since their publication.[11] However, although this is true, the RCTs in our study have been cited in many different journals with widely varying lag times between acceptance of an article to its actual publication. We do not suspect this to bias our results because there is no empirical evidence to date documenting that certain journals are cited more often after 24 months when compared with others. Because the observation period was the same for all articles, we do not expect it to adversely affect our study findings.

In our study, we selected only published RCTs, and examined the relative impact of several independent variables including the publishing journal, geographic region, funding source, number of authors, study subjects, presentation of a significant result, and the number of references on citation counts. It is critically important that all published RCTs provide a CONSORT statement and stick to the protocol mentioned in the CONSORT statement. It has been suggested that adopting the CONSORT guidance improves the quality of study reporting.[12]

It is quite possible that the articles included in our study differ in their quality. During the past few years, several studies have examined the quality of RCTs published in dentistry. Montenegro and colleagues[13] conducted

TABLE 4. *P* values for comparison of citation counts by journal: multiple post hoc tests using Man-Whitney *U* test (*P* values < .008 are statistically significant)

Study design	Clinical Oral Investigations	European Journal of Oral Sciences	Journal of Dentistry	Journal of Dental Research
Clinical Oral Investigations	—	.363	.062	.23
European Journal of Oral Sciences		—	.277	.03
Journal of Dentistry			—	<.0001*
Journal of Dental Research				—

*Statistically significant after adjusting by Bonferroni corrections.

TABLE 5. Incident rate ratio estimates of number of citations during the observation period (multivariable negative binomial regression analysis)

Independent variables	Incident rate ratio	95 % confidence intervals	*P* value
Journal			
Clinical Oral Investigations	0.56	0.31–1.06	.052
European Journal of Oral Sciences	0.53	0.32–0.90	.018*
Journal of Dentistry	0.49	0.31–0.76	.001*
Journal of Dental Research	Reference		
Continent			
North America	0.76	0.47–1.22	.252
South America	0.64	0.38–1.09	.101
Asia/Oceania	0.92	0.59–1.45	.721
Europe	Reference		
Funding source			
US government	1.95	0.97–3.93	.06
Exclusively non–US government	0.96	0.66–1.41	.847
Not funded	Reference		
Animal study			
Yes	1.07	0.50–2.29	.869
No	Reference		
Significant result in study			
Yes	1.29	0.84–1.96	.243
No	Reference		
No. of authors (every 1 unit increase)	1.11	1.02–1.20	.017*
No. of references (every 1 unit increase)	1.02	1.01–1.04	.001*

*Statistically significant.

a systematic review to examine the quality of RCTs published in *Periodontology* and found that only 17% of the reviewed studies described adequately the methods of randomization whereas allocation of concealment was described in only 7% of the studies. They concluded that RCTs in *Periodontology* do not meet the recommended standards.[13] In another study, Falagas et al[14] investigated the trends of methodological quality of RCTs of antimicrobial agents published over a 30-year period from 1975 through 2005 and observed that there was no improvement in the quality of reporting and methodological rigor of RCTs. The methodological quality of RCTs published in the field of implant dentistry and their influence on subsequent research was investigated by Nieri et al,[15] who found that there were several critical methodological and statistical flaws in these RCTs and concluded that these studies may not be appropriate for guiding clinicians in their practice. All these studies suggest the importance of conducting high-quality RCTs in dentistry and improving the reporting standards of study findings.

TABLE 6. *P* values for comparison of citation counts by funding source: multiple post hoc tests using Man-Whitney *U* test (*P* values < .016 are statistically significant)

Study design	US government	Exclusively non–US government	Not funded
US government	—	.004*	.001*
Exclusively non–US government		—	.258
Not funded			—

*Statistically significant after adjusting by Bonferroni corrections.

We did not examine the association between the quality of an RCT and the citation counts. It is reasonable to hypothesize that high-quality (well-designed) RCTs have higher citation counts, as compared with a low-quality (poorly designed) study. However, several studies across different specialties have shown that the quality of a published article is not associated with citation counts.[16,17] In addition, we did not exclude self-citations in the citation counts. Even though multidisciplinary journals, such as the ones selected in our study, tend to have low journal specific self-citation rates (the journal-specific self-citation rates as of the year 2007 for *Journal of Dental Research* and *European Journal of Oral Sciences* were only 3% whereas the journal-specific self-citation rates for *Journal of Dentistry* and *Clinical Oral Investigations* were 9%[10]), our study results could still be biased by journal-specific citation rates. We did not account for author-specific self-citation rates in our study. Previous studies have shown that author self-citations could affect citation counts of articles.[18]

Although we examined the role of several independent variables on citation counts, it is possible that there are other confounding factors not captured by this study that could influence citation counts. All regression analyses in our study are limited to the data that we captured. Consequently, there is a potential for omitted variable bias. There could be a host of other factors that may influence citation counts and their role should be examined in future studies.

CONCLUSIONS

Based on our initial analysis of 4 journals, publishing randomized trials in high-impact journals will likely provide better dissemination of research findings.

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