Introspection
An Analysis of the Citation Impact of Stroke
Myron D. Ginsberg, MD

One indicator of the influence of a scientific journal is the extent to which its articles are cited by others. A widely applied measure in this regard is so-called journal impact factor, an index devised by Eugene Garfield to quantify the extent to which the articles of that journal are cited in other peer-reviewed publications. The impact factor is typically computed as the quotient A/B, where A is the total number of times that articles published in a journal in 2 consecutive years (eg, 2008 and 2009) were cited in articles published during the following year (eg, 2010), and B is the total number of “citable items” published by that journal in those 2 years (see “impact factor” on Wikipedia [accessed July 21, 2011]). As quoted by Lo and Fisher in their recent editorial, the 2009 impact factor for Stroke was 7.041, compared to 8.172, 9.317, and 18.126 for the journals Neurology, Annals of Neurology, and Lancet Neurology, respectively. An obvious shortcoming of the impact factor, so-computed, is that it represents merely a numeric average that does not shed light on the extent to which the individual articles of a journal contribute to its overall citation impact. Thus, the intent of the present contribution is to provide an expanded analysis of the citation impact of articles and reviews published in Stroke in the years 2008 and 2009.

Materials and Methods
The present analysis utilized the Scopus database (SciVerse ScienceDirect, Elsevier), a large online abstract and citation database of the world’s peer-reviewed literature in the world that provides citation data current as of the date-of-search. All “articles + reviews” published in the journal Stroke during the calendar years 2008 and 2009 were accessed, and their citation numbers as of the date of search (August 29, 2011) were tabulated. Note that whereas this search strategy excludes editorials and letters, it does not exclude reviews; it accesses citation numbers up to the date of search (rather than only during the subsequent calendar year, as is the case in the traditional impact factor computation). To gain a deeper understanding of citation trends for Stroke, each of the individual articles and reviews comprising the most cited and least cited quintiles (Table 1, n=234 each) was categorized and subcategorized according to the thematic rubrics presented in Table 2 by utilizing information contained in its abstract or, if needed, in its Methods section. In addition, the country of origin of each contribution was tabulated; articles originating from multiple countries were attributed to the country of the first author. The χ² analysis was used for overall comparisons, and the Fisher exact test was used for individual categories.

A citation analysis also was performed of cerebrovascular articles published in selected major general neurology journals in 2008 and 2009 to allow comparisons with recently published data.

Results
A total of 1168 “articles + reviews” were published in Stroke during 2008 and 2009, and these articles had been cited in other publications a total of 16,979 times as of the date of search. Figure 1 presents a citation histogram for these 1168 papers, and Table 1 shows the citation data by quintiles. As expected, the distribution shown in Figure 1 departs markedly from a normal (ie, Gaussian) distribution. Thus, whereas the mean value of citations per article is 14.5, the median value is 10; that is, one-half of the articles published in Stroke in 2008 and 2009 were cited ≤10 times over the ensuing 20 months, and 25% of articles received ≤5 citations. Twenty-four articles and reviews were never cited in other publications in the ensuing 20 months, and another 79 articles were cited only once or twice.

At the other extreme, 35 articles (or 3%) were cited >50 times, and 7 articles (or 0.6%) received >100 citations. It is instructive to consider the subjects of the most highly cited papers, and their citation numbers as of the date of search (August 29, 2011) were tabulated. Note that whereas this search strategy

Table 1. Citations for Articles and Reviews (N=1168) Published in Stroke in 2008 and 2009

<table>
<thead>
<tr>
<th>Quintile</th>
<th>First (Least Cited)</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
<th>Fifth (Most Cited)</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of citations</td>
<td>604</td>
<td>1450</td>
<td>2425</td>
<td>3859</td>
<td>8641</td>
<td>16,979</td>
</tr>
<tr>
<td>Mean citations per article</td>
<td>2.6</td>
<td>6.2</td>
<td>10.4</td>
<td>16.6</td>
<td>36.9</td>
<td>14.5</td>
</tr>
<tr>
<td>SD citations per article</td>
<td>1.4</td>
<td>1.0</td>
<td>1.5</td>
<td>2.3</td>
<td>25.1</td>
<td>16.6</td>
</tr>
</tbody>
</table>

SD indicates standard deviation.

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Table 2. Thematic Categorization of the Most Cited and Least Cited Quintiles

<table>
<thead>
<tr>
<th>Category Subcategory</th>
<th>No. of Articles, Most Cited Quintile</th>
<th>No. of Articles, Least Cited Quintile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Category Sum</td>
<td>Subcategory Sum</td>
</tr>
<tr>
<td>CLINICAL</td>
<td>Total = 187</td>
<td>Total = 203</td>
</tr>
<tr>
<td>Multicenter randomized controlled trial*</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td>Secondary analysis</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Meta-analysis</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Other types of multicenter studies†</td>
<td>29</td>
<td>16</td>
</tr>
<tr>
<td>Secondary or other analysis</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Meta-analysis</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Smaller randomized controlled trial‡</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Treatment comparison</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Other types of smaller trials§</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Descriptive articles¶</td>
<td>102</td>
<td>22</td>
</tr>
<tr>
<td>Primarily clinical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primarily MRI and neuroimaging**</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Primarily laboratory-based††</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>Database or population analysis‡‡</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Device, modeling, simulation, other</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Major guidelines articles</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Conference recommendations</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Brief review and/or opinion pieces¶¶</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>BASIC</td>
<td>Total = 47</td>
<td>Total = 31</td>
</tr>
<tr>
<td>Animal studies</td>
<td>34</td>
<td>28</td>
</tr>
<tr>
<td>In vitro studies</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Methodology, computational modeling</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Review article</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Conference recommendations</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>234</td>
<td>234</td>
</tr>
</tbody>
</table>

MRI indicates magnetic resonance imaging.

*Multicenter randomized controlled trial*: multicenter trials that are prospectively designed, randomized, blinded, and placebo-controlled.
†“Other types of multicenter studies”: multicenter observational studies that do not conform to the definition of *, eg, are not prospectively designed and/or not placebo-controlled (eg, case-control, cohort design, and others) and/or not blinded.
‡“Smaller randomized controlled trial”: smaller typically nonmulticenter trials that conform to the design requirements listed in *.
§“Other types of smaller trial”: smaller typically nonmulticenter observational studies that do not conform to the definition of *, eg, are not prospectively designed and/or not placebo-controlled (eg, case-control, cohort design, and others) and/or not blinded.
¶Descriptive articles are distinguished from articles designated as “trials” in that the primary intent of the former is to describe the characteristics of a single designated group (using continuous or categorical variables) and only subsequently to explore relationships among these observations. By contrast, the explicit primary (a priori) intent of a “trial” is to compare the characteristics of ≥2 groups.
||Primarily clinical||: descriptions of clinical series (variously prospective, retrospective, cross-sectional, chart-review-based, and others; variously combined with neuroimaging, genetic analysis, or other laboratory variables).
***Primarily MRI and neuroimaging**: may also include clinical or genetic analyses.
††“Primarily laboratory-based”: variously emphasizing clinical chemistry; physiological variables; protein, mRNA, or cell analysis; pathological findings and others.
‡‡“Database or population analysis”: typically based on clinical or epidemiological databases and registries, often involving several hundreds or thousands of subjects.
§§“Literature review”: thorough topic reviews with many references.
¶¶“Brief review and/or opinion pieces**: typically brief (1–2 pages) and usually lacking an abstract.
||Eight of these are reports of only 1 or 2 cases.

Special Writing Group report on the management of stroke in infants and children;7 article 5 (111 citations) was the report of a pivotal clinical trial of the Penumbra revascularization device;8 article 6 (104 citations) was an AHA/ASA scientific advisory concerning the use of intravenous tissue plasminogen activator within an expanded time window;9 and article 7 (102 citations) was an AHA/ASA scientific statement on the definition and evaluation of transient ischemic attack.10 To-
Figure 1. The bar graph is a histogram showing citation numbers for articles and reviews published in Stroke in 2008 and 2009 (left axis). The curved line shows the cumulative percentage of total citations for these articles and reviews (right axis).

Together, these 7 articles (or 0.6% of the total) accounted for over 6% of the total citations of Stroke articles published in 2008 and 2009.

Table 2 presents in detail the categories and subcategories used to classify each of 234 articles or reviews comprising the most cited and least cited quintiles published in Stroke during 2008 and 2009 (Table 1). Figure 2 provides a graphic comparison of the major thematic categories. The complete data set used in this analysis is contained in the online-only Data Supplement (http://stroke.ahajournals.org). Overall, clinical themes accounted for 80% and 87% of articles in the most cited and least cited quintiles, respectively; basic science themes comprised the remaining 20% and 13%. The clinical/basic proportion did not differ significantly between these quintiles (P value not significant, Fisher test). Of the clinical articles, the most cited quintile contained a much higher proportion of multicenter clinical trial reports than the least cited quintile (30% versus 6%; P < 0.0001, Fisher test; Table 2, Figure 2), as well as a significantly greater proportion of detailed literature reviews (9% versus 2%; P = 0.003, Fisher test) and major Guidelines articles (4% versus 0%; P = 0.003). By contrast, the least cited quintile contained much higher proportions of brief clinical review and/or opinion pieces (most cited quintile, 1%; least cited quintile, 19%; P < 0.0001, Fisher test), as well as a higher proportion of primarily descriptive analyses (most cited quintile, 55%; least cited quintile, 69%; P = 0.003). A common characteristic of the 9 multicenter randomized clinical trials falling into the least cited quintile was that these studies were either entirely negative (6 studies) and/or they reported secondary analyses of trials with primary outcomes that had been reported elsewhere (3 studies).

Another manner of viewing these results is to consider the pool of 468 articles comprising the highest cited quintile plus lowest cited quintile and to analyze manner in which various article types are distributed between these respective groups. Of the 36 multicenter trial reports appearing in these 2 groups, 75% were within the highest cited quintile and 25% were in the lowest cited quintile. Similarly, a disproportionate number of "other types of multicenter studies" (91%) were in the highest cited quintile, and only 9% were in the lowest cited group. A similar trend was seen for major guidelines articles (100% versus 0%). By contrast, "brief review and/or opinion pieces" were overwhelmingly distributed within the lowest cited quintile (95%) as compared to the highest cited quintile (5%).

Countries of origin are shown in Table 3. The majority of articles originated in North America or Europe. Comparison of the most cited and least cited quintiles failed to reveal any important intergroup differences in this respect (χ² = 9.8; 5 degrees of freedom; P value not significant).

In their recent editorial, Lo and Fisher² compared the citations accorded the 25 most highly cited articles in Stroke over the past 10 years with the most highly cited cerebrovascular articles in 3 leading general neurology journals during that period. The present analysis adopted a similar but broader strategy using the same search terms ("stroke OR cerebral ischemia OR cerebral hemorrhage [topic]"); date of search: July 20, 2011).² The results are shown in Figure 3, which compares all citations of 2008 to 2009 articles in Stroke with citations of 2008 to 2009 cerebrovascular articles in Neurology, Annals of Neurology, and Lancet Neurology. There is considerable distributional overlap between Stroke and Neurology; the curve for cerebrovascular articles in Annals of Neurology is largely similar but with a greater proportion of highly cited articles, while cerebrovascular articles in Lancet Neurology are, overall, much more highly cited.
cited than those of the other 3 journals. Admittedly, the numbers of articles from the general neurology journals on which these curves are based are very small in comparison with Stroke (Figure 3).

Discussion

It is evident from this analysis that individual articles in Stroke contribute in a markedly uneven manner to its overall citation impact. The most highly cited articles in Stroke are AHA/ASA management guidelines articles, major scientific advisories, and reports of multicenter randomized clinical trials. In contrast to the most cited articles, the least cited group contains a much higher proportion of brief review and/or opinion pieces, as well as more nontrial-based descriptive clinical reports.

The results of this analysis thus indicate that the citation impact of the journal Stroke would be predictably enhanced if it could attract a greater proportion of publications reporting major randomized clinical trial results. This is admittedly difficult to achieve, however, given the strong competition of first-rank general clinical journals (eg, New England Journal of Medicine, JAMA, Lancet) for these reports. The AHA/ASA Guidelines articles, major scientific advisories, and detailed well-referenced literature reviews also tend to be highly cited. By contrast, brief review and/or opinion pieces (typically 1–2 pages and lacking an abstract), despite their possible appeal to the general readership, tend to have a very low citation impact. Nontrial-based reports of a purely descriptive nature, whether emphasizing primarily clinical, neuroimaging, or other laboratory measures, tend to be highly represented among the most cited as well as the least cited Stroke articles.

For these articles, it becomes critical for the reviewers of Stroke to be able to discern the potential impact of an article in deciding on acceptance or rejection. Regarding editorial policy, it might be considered whether Stroke would be better-served by decreasing its total number of published articles by rejecting an additional percentage of those predicted to have very low impact while increasing the page length devoted to important articles and topics judged likely to become highly cited.

Lo and Fisher call attention to the enormous number of electronic “views” (ie, online accesses) of the content of Stroke (>5 million in 2010). This impressive fact underscores that the “impact” of Stroke must be gauged in terms beyond those reflected in citation statistics. In this regard, it would be of great interest for the Stroke editors to analyze the full-article online views in greater detail and, if possible, to develop article-by-article “view” statistics comparable with the citation statistics presented here. The results of such an analysis might further guide future editorial policies regarding journal content and emphasis.
**Disclosures**

None.

**References**


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http://stroke.ahajournals.org/content/early/2012/04/05/STROKEAHA.111.640235.citation

Data Supplement (unedited) at:
http://stroke.ahajournals.org/content/suppl/2012/04/06/STROKEAHA.111.640235.DC1

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