Measuring individual academic and scientific productivity has become increasingly important in determining tenure and promotions at academic institutions. It also influences grant awards and nominations to scientific societies on a national level. Measuring academic productivity, however, is a difficult task. Bibliometric formulae have been developed to objectively assess an individual’s scientific contribution but are not standardized across scientific fields or across medical specialties. Historically, the productivity metric most used in the medical field was the impact factor of the journal in which the paper was published. The impact factor was first proposed by Garfield and Sher in 1963 and is still published by the Thompson Reuters group on an annual basis. However, the impact factor only measures the quality of a journal as a whole, not the individual papers it publishes, and it is limited in that current medicine trends, self-citation (of the journal), and the size of the field of research can all significantly affect the value.

Methods. Programs with an Accreditation Council for Pediatric Neurosurgery Fellowships–approved fellowship were identified, and the h and g indices of each of their surgeons were calculated. These were correlated with academic rank and compared with published literature on academic neurosurgical departments.

Results. Seventy-two pediatric neurosurgeons had a mean h index of 16.6 and a mean g index of 29.5. Both indices increased with progressive academic rank. The rank-specific mean index for academic pediatric neurosurgeons was similar to that of neurosurgeons from academic departments in general.

Conclusions. Overall, the authors conclude that the h index metric is a reasonable measure of academic productivity in the pediatric neurosurgery arena that provides a robust measure of an individual’s contribution to the pediatric neurosurgery literature. Like its counterpart in neurosurgery in general, the h index for pediatric neurosurgeons correlates with institutional rank. The h index calculation also reveals the productivity of the pediatric neurosurgeons to be on par with the productivity of neurosurgeons in general.

More rudimentary measures of individual productivity have also included the number of papers published by an individual (quantity of productivity) and the number of times a paper was cited (quality of productivity). These single measures, however, are not able to assess the scientific impact of the papers or the longevity of productivity, respectively. In an effort to measure fairly and objectively both the quality and the quantity of an individual’s productivity, physicist Jorge Hirsch developed the eponymous h index in 2005. The h index attempts to evaluate reliably and consistently the number of papers published by an author, their impact on the field, and the longevity of the impact. It is determined as follows: “a scientist has the index h if h of his or her Np papers have at least h citations each and the remainder of the papers (Np – h) have ≤ h citations each, where Np is the number of papers published over n years.” For example, if an author has 10 publications that have been cited 25, 24, 20, 19, 19, 17, 8, 2, 2, and 1 times, his or her h index would be 7 because there are 7 publications with more than 7 citations.

Hirsch included some caveats with the use of h index, but proposed a scale to convert the h index into meaningful criteria for faculty promotions and tenure.

The caveats described by Hirsch identify some of the
The $h$ index in pediatric neurosurgery

shortcomings of the $h$ index. In particular, the $h$ index is highly affected by the length of an individual’s career. This would be corrected if the $h$ index was limited to a certain recent period of time (for example, to the last 5 years). The effort contributed by the author on multi-author papers (author order) is not accounted for in an author’s $h$ index. The $h$ index also does not account for very important, highly cited articles. In 2006, Leo Egghe suggested the $g$ index to address the shortcomings of the $h$ index and adjust for the caveats. The $g$ index is a variation of the $h$ index that gives more weight to highly cited articles. It addresses the concerns that additional citations for highly successful papers do not alter the $h$ index metric to reflect the true quality of a researcher.

Since the proposal of the $h$ index in 2005 and the $g$ index in 2006, basic science fields including physics and biology have rapidly adopted these measures in determinations of promotions and tenure. More recently, subspecialties within medicine have started to adopt the $h$ index as a measure of productivity and have demonstrated its correlation with rank.

Some evidence suggests that the $h$ index varies from one scientific field to another as a result of the number of investigators and the overall citation rate. We were therefore interested in studying the $h$ index within pediatric neurosurgery. Our goal was to compare the $h$ index and the $g$ index with the rank of faculty in academic pediatric neurosurgery programs and with the published data from academic neurosurgery departments.

Methods

Calculation of $h$ Index and $g$ Index

To compile a cohort of academic pediatric neurosurgeons in North America in 2012, a list of all programs with a fellowship approved by the ACPNF was derived from the ACPNF website (http://acpnf.org). The pediatric neurosurgeons at each of these programs were identified, and an $h$ index and a $g$ index were calculated for each and correlated with academic rank. Google Scholar was selected as the main database because of its availability and publication longevity. Harzing’s Publish or Perish (http://www.harzing.com/pop.htm) software was used to search the Google Scholar database. Results were identified using last name and first initial. The searches were limited to “Biology, Life Sciences, Environmental Sciences” and “Medicine, Pharmacology, Veterinary Sciences” fields. The resulting queries were cross-checked to ensure the correct author was identified based on co-authors, article titles, and subject-specific journals. Any erroneous references were removed, and the $h$ and $g$ indices were recalculated. For academic rank, department websites were searched. In cases in which faculty rank could not be determined via the website, the department was contacted directly.

The $h$ and $g$ indices for academic pediatric neurosurgeons were compared with published data from 30 academic departments in the US. Indices were described with means and 95% confidence intervals and compared with 1-way ANOVA by using SPSS Statistics version 20.0 (2011).

Results

We identified 72 pediatric neurosurgeons in the ACPNF-approved programs. We excluded pediatric neurosurgeons serving as department chairs because of their administrative roles. The mean $h$ index for all 72 pediatric neurosurgeons was 16.6, and the mean $g$ index was 29.5. Our data showed that $h$ index and $g$ index calculated via Google Scholar correlated with faculty rank. The mean (95% CI) $h$ index as calculated by faculty rank was 7.8 (5.6–9.9) for assistant professors, 13.0 (10.6–15.5) for associate professors, and 27.9 (23.2–32.5) for professors (Fig. 1, Table 1). The mean $g$ index for each rank was 14.5 (10.1–19.0) for assistant professors, 25.0 (19.5–30.5) for associate professors, and 48.0 (40.5–55.5) for professors (Table 1). Comparing the calculated $h$ and $g$ index values for each pe-

### TABLE 1: The $h$ and $g$ indices by rank for pediatric neurosurgeons

<table>
<thead>
<tr>
<th>Rank</th>
<th>Range</th>
<th>Mean h Index (95% CI)</th>
<th>Mean g Index (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>assistant professor (n = 25)</td>
<td>1–21</td>
<td>7.8 (5.6–9.9)</td>
<td>14.5 (10.1–19.0)</td>
</tr>
<tr>
<td>associate professor (n = 24)</td>
<td>3–29</td>
<td>13.0 (10.6–15.5)</td>
<td>25.0 (19.5–30.5)</td>
</tr>
<tr>
<td>professor (n = 23)</td>
<td>11–52</td>
<td>27.9 (23.2–32.5)</td>
<td>48.0 (40.5–55.5)</td>
</tr>
<tr>
<td>p &lt;0.001</td>
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neurosurgeons. In recent years, the h index and its variations have become important tools in assessing the academic productivity of scientists. Specifically in the medical specialties, the h index correlates with academic rank of individual faculty as well as overall departmental research funding. Lozano et al. in the field of general neurosurgery, Lee at al. To assess the validity of the h index, specifically among academic pediatric neurosurgeons.

As others have found, the h index as determined using Google Scholar was strongly correlated with academic rank. As a matter of fact, the 95% confidence intervals on the mean h index and the mean g index didn’t overlap between the ranks of assistant, associate, and full professor.

We were also interested in determining whether the h index score was specific to pediatric neurosurgeons, and therefore compared our findings with the published literature on academic neurosurgeons in general. We found similar h indices at the ranks of assistant and associate professor and a slight divergence of the mean h index at the professor level, which may simply reflect the small sample size of pediatric neurosurgery professors.

**Discussion**

In recent years, the h index and its variations have become important tools in assessing the academic productivity of scientists. Specifically in the medical specialties, the h index correlates with academic rank of individual faculty as well as overall departmental research funding. Lozano et al. in the field of general neurosurgery, Lee et al. randomly selected 30 academic programs across the US and computed the h index of the faculty by using online publication databases. Their results indicated a “robust” linear relationship between academic productivity as measured by the h index and career success. Similarly, Ponce and Lozano evaluated all US and Canadian neurosurgical programs, a total of 99 institutions, and confirmed that the h index correlated with more traditional measures of departmental success including grants, number of publications by the department, and academic orientation of faculty. Although the h index has been deemed a reliable measure for neurosurgery, Radicchi et al. showed that the index itself is only a valid metric within a specific field and that comparison across scientific fields or even medical specialties is not valid because of the widely disparate number of investigators in each field. We were therefore interested in assessing the h index, specifically among academic pediatric neurosurgeons.

Overall, we conclude that the h index metric is a reasonable measure of academic productivity in the pediatric neurosurgery arena. It provides a robust measure of an individual’s contribution to the pediatric neurosurgery literature. Like its counterpart in neurosurgery in general, the h index for pediatric neurosurgeons correlates with academic rank. The h index calculation also reveals the productivity of the pediatric neurosurgeons to be on par with the productivity of neurosurgeons in general.

**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Kestle. Acquisition of data: Kestle. Analysis and interpretation of data: both authors. Drafting the article: both authors. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Kestle. Statistical analysis: Kestle.

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| TABLE 2: The h index by rank for neurosurgical faculty in pediatric programs and neurological departments |
|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Rank               | Mean h Index in Pediatric Programs (95% CI) | Mean h Index in Neurosurgical Departments (95% CI) |
| assistant professor | 7.8 (5.6–9.9)                    | 5.1 (2.1–8.0)                  |
| associate professor | 13.0 (10.6–15.5)                 | 10.7 (7.7–13.7)                |
| professor           | 27.9 (23.2–32.5)                 | 16.0 (13.0–19.0)               |
|                    | p <0.001                        | p <0.0001                      |

**Conclusions**

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The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Kestle. Acquisition of data: Kestle. Analysis and interpretation of data: both authors. Drafting the article: both authors. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Kestle. Statistical analysis: Kestle.

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