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# The Worldwide Influence of Social Media on Cervical Spine Literature

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## ABSTRACT

**Background:** The Altmetric (Digital Science, Holtzbrinck Publishing) Attention Score (AAS) is an automatically calculated score that accounts for other literary influences, which include academic sources as well as nonacademically focused social media outlets such as Twitter, Facebook, and news articles. This study compares the most popular cervical surgery articles on social media to the most cited articles within peer-reviewed literature and identifies journals that contribute the most articles and geographic trends.

**Methods:** We searched the Altmetric database for cervical spine surgery articles since inception using the search phrase “cervical” and “spine.” We ranked journals that contributed the most articles and calculated their AAS, contributing social media outlets (eg, Twitter, Facebook, News, etc) and citation counts. We also ranked the top 100 most popular cervical spine articles on social media and compared them to the most cited articles. Countries were assessed based on their mentions through the most contributing social media platform.

**Results:** Of the 527 total journals identified in our search, the top 10 journals were responsible for contributing 60.2% of the total articles. The 3 journals that contributed the most articles were *Spine* (18.9%), *European Spine Journal* (11.8%), and *The Spine Journal* (10.3%). The journals with the highest AAS scores included *Journal of Neurosurgery: Spine* (11.3), *Spine* (8.8), and *Journal of Manipulative & Physiological Therapeutics* (5.8). Social media outlets that contributed the most mentions per article were Twitter (4.4), Facebook (0.5), and news sources (0.3). Among all countries contributing Twitter mentions, the 3 countries with the most cervical spine posts included the United States (23.3%), the United Kingdom (10.3%), and Spain (5.5%).

**Conclusion:** Our evaluation of cervical spine literature revealed Twitter, Facebook, and news sources are the most common social media outlets influencing title dissemination. Journals contributing the most articles did not necessarily have the highest average AAS.

**Clinical Relevance:** Spinal surgeons should consider utilization of social media outlets, such as Twitter, Facebook, and news sources, to potentially increase the dissemination of their articles.

**Level of Evidence:** 3.

Cervical Spine

Keywords: altmetric, cervical spine, literature, social media

## INTRODUCTION

Although keyword searches or browsing journal databases for formal medical publications have been the standard methods for scholars to obtain information, the rise of social media has greatly expanded the public's exposure to scientific literature. In recent years, authors and publishers have been more inclined to share their research over the internet to expand readership interest; this increases not only the attention the articles received but also their impact on public perception.<sup>1</sup> Historically, the influence of journals on clinical decision-making and public policy has been quantified in terms of impact factor, while individual articles are assessed in terms of citation rates.<sup>2–4</sup> However, a number of concerns have

been raised regarding the reliability of these measures, including self-citation bias, politics, and, at times, uncertainty surrounding the validity of the article's information.<sup>5</sup> Additionally, some argue that citation rates take too long to accumulate and are therefore not a timely or accurate measure of impact.<sup>5</sup> To underline this point, a 2016 study of the most cited articles in cervical spine surgery reported that the largest number of these were published in 1990s, indicating that by this metric, the most “influential” articles are roughly 2 decades old.<sup>6</sup>

The Altmetric Attention Score (AAS) is a more recently developed metric purported to account for the shortcomings of more traditional impact measures. This score is derived using an algorithm that calculates the amount of attention a specific article has received based on the

volume of mentions, sources, and author references from various web-based platforms, including social media such as Twitter and Facebook.<sup>7</sup> Although this metric is a more recent development, it has been suggested to complement the conventional impact factor and citation rates by also accounting for more widespread and publicly accessible online influence rather than strictly focusing on citation counts.<sup>8</sup>

The influence of platforms like Facebook and Twitter, along with current advances in technology can be attributed to the now nearly 72% of Americans reporting they use social media.<sup>9</sup> As social media increasingly facilitates rapid and far-reaching transmission of information, its popularity and influence in medicine are unsurprising. However, the ease with which online content is disseminated without a review process may allow the spread of misinformation, potentially distorting a patient's perception of treatment or promoting unrealistic expectations.<sup>10</sup> Recent reports of social media's ability to drastically influence medical beliefs and practices make the potential for such misinformation all the more concerning, highlighting the need to thoroughly understand social media's role with regard to medical literature.<sup>11</sup>

As the production of scientific literature related to spine surgery has substantially increased over the last 10 years, a parallel can be drawn to the presence of spine surgeons on social media, who now represent approximately 8% of all surgeon influencers on social media platforms such as Twitter, Facebook, and Instagram.<sup>9-11</sup> Altmetrics have previously been reviewed for spine literature by Parrish et al.<sup>12</sup> However, while lower back pain and pathology of the lumbar spine may be relatively common topics in the public sphere, literature related to the cervical spine may be considered more specialized and viewed by a more narrow readership.<sup>1,13</sup> Moreover, anatomical variations in the procedures that correct the different etiologies of cervical diseases likely translate to differences in the type of content seen across various platforms. Therefore, an analysis of the influence of social media on the dissemination of literature specifically related to the cervical spine is warranted.

While an overwhelming majority of articles on the lumbar, cervical, and thoracic spine come from the United States,<sup>14</sup> consideration of other regions across the globe is important in order to understand their role in the propagation and consumption of spine-related literature. With over 3.5 billion social media users worldwide,<sup>15</sup> the AAS is the perfect metric to track a journal or article's global impact, providing valuable insight into the topics of interest across the globe. This information will be valuable for surgeons not only to conceptualize global trends in cervical spine

readership but also to discern which social media outlets are most useful for reaching a substantial amount of readers. Our literature review sets out to compare and contrast the most popular cervical spine literature on social media with the most cited articles and identify global geographic trends in social media activity related to the cervical spine.

## METHODS

### Data Collection

The Altmetric database was searched for cervical spine surgery articles since the inception of the database's records using the search terms "cervical" and "spine." The following bibliometric values were collected for each journal and article returned using the Altmetric database: number of cervical spine-related articles, overall Altmetric score, news mentions, mentions in public policy documents, references in patents filed with 9 international patent offices, mentions on Twitter, mentions on Facebook, number of readers who saved an article to their Mendeley library, and number of citations in the Dimensions research network database. The study design of each article was also collected and included the following categories: retrospective studies, prospective studies, systematic reviews, review articles, case studies, clinical guidelines, cadaveric studies, biomechanical studies, basic science studies, opinion articles, commentaries, and books. Finally, the country of origin was determined for all social media mentions of cervical spine-related literature and charted on a heatmap.

### Statistical Analysis

For each journal, descriptive statistical analysis was performed to determine the proportion of cervical spine articles published and ranked by the number of articles published. Additionally, descriptive analysis was performed for the Altmetric score as well as mentions through news, policy, patent, Twitter, and Facebook. The mean number of Mendeley readers and number of Dimensions citations were also calculated for each journal. Through separate analyses using AAS and the number of citations, the top 100 articles were identified for each of these 2 metrics. The top 100 articles were based on each metric and were compared in terms of article category.

## RESULTS

Our search returned 3712 academic articles or books. Of the 527 total journals identified in our search, the top 10 journals were responsible for contributing 60.2% of the total articles. Overall, the top 10 journals had

**Table 1.** The top 10 journals contributing cervical spine literature with mean  $\pm$  SD bibliometric values.

Journal/Collection Title	Articles, % (n)	Altmetric Score	News Mentions	Policy Mentions	Patent Mentions	Twitter Mentions	Facebook Mentions	Number of Mendeley Readers	Number of Dimensions Citations
<i>Spine</i>	12.3% (637)	8.8 $\pm$ 65.5	0.7 $\pm$ 4.8	0.0 $\pm$ 0.2	0.0 $\pm$ 0.2	5.8 $\pm$ 56.6	0.6 $\pm$ 5.8	30.0 $\pm$ 24.5	20.2 $\pm$ 25.2
<i>European Spine Journal</i>	7.7% (398)	2.4 $\pm$ 6.2	0.1 $\pm$ 0.8	0.0 $\pm$ 0.1	0.0 $\pm$ 0.1	2.3 $\pm$ 4.4	0.5 $\pm$ 1.9	23.6 $\pm$ 22.9	11.2 $\pm$ 15.6
<i>The Spine Journal</i>	6.7% (348)	4.9 $\pm$ 22.4	0.4 $\pm$ 2.7	0.0 $\pm$ 0.1	0.0 $\pm$ 0.0	3.9 $\pm$ 13.8	0.2 $\pm$ 0.9	24.8 $\pm$ 31.7	9.9 $\pm$ 17.6
<i>Journal of Neurosurgery: Spine</i>	4.6% (239)	11.3 $\pm$ 53.4	1.1 $\pm$ 7.2	0.0 $\pm$ 0.2	0.1 $\pm$ 1.9	6.3 $\pm$ 10.5	0.8 $\pm$ 1.4	28.0 $\pm$ 29.1	17.8 $\pm$ 33.0
<i>Global Spine Journal</i>	3.1% (161)	2.4 $\pm$ 2.5	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	3.8 $\pm$ 5.2	0.4 $\pm$ 0.9	17.5 $\pm$ 17.2	6.4 $\pm$ 8.5
<i>Clinical Spine Surgery</i>	2.8% (144)	3.0 $\pm$ 3.4	0.2 $\pm$ 0.5	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	3.0 $\pm$ 2.1	0.6 $\pm$ 0.8	13.7 $\pm$ 13.4	5.6 $\pm$ 8.4
<i>Contemporary Spine Surgery</i>	0.6% (32)	1.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	2.0 $\pm$ 0.9	1.1 $\pm$ 1.0	1.4 $\pm$ 2.6	0.3 $\pm$ 1.1
<i>Asian Spine Journal</i>	0.5% (25)	1.6 $\pm$ 2.4	0.1 $\pm$ 0.3	0.0 $\pm$ 0.2	0.0 $\pm$ 0.0	0.6 $\pm$ 1.2	0.2 $\pm$ 0.5	14.5 $\pm$ 14.9	7.2 $\pm$ 8.1
<i>Journal of Manipulative &amp; Physiological Therapeutics</i>	0.5% (25)	5.8 $\pm$ 10.1	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	5.7 $\pm$ 10.8	2.9 $\pm$ 8.3	61.3 $\pm$ 58.4	9.8 $\pm$ 12.8
<i>World Neurosurgery</i>	0.5% (25)	1.5 $\pm$ 1.9	0.1 $\pm$ 0.3	0.0 $\pm$ 0.2	0.0 $\pm$ 0.0	0.9 $\pm$ 0.9	0.1 $\pm$ 0.4	18.0 $\pm$ 14.8	8.6 $\pm$ 14.3
Overall	100% (3712)	5.5 $\pm$ 35.3	0.3 $\pm$ 3.3	0.0 $\pm$ 0.2	0.0 $\pm$ 0.5	4.4 $\pm$ 26.9	0.5 $\pm$ 2.9	24.5 $\pm$ 32.5	10.5 $\pm$ 18.9

a mean Altmetric score of  $5.5 \pm 35.3$ , with an average number of Twitter mentions of  $4.4 \pm 26.9$  and Facebook mentions of  $0.5 \pm 2.9$  (Table 1). Additionally, the top 10 Journals received an average of  $10.5 \pm 18.9$  Dimension citations.

The 3 journals that contributed the most articles were *Spine* (18.9%), *European Spine Journal* (11.8%), and *The Spine Journal* (10.3%). The journals with the highest AAS scores included *Journal of Neurosurgery: Spine* (11.3), *Spine* (8.8), and *Journal of Manipulative & Physiological Therapeutics* (5.8). The average AAS for all articles was 5.5. Social media outlets that contributed the most mentions per article were Twitter (4.4), Facebook (0.5), and news sources (0.3).

The top 100 ranking articles by AAS and the top 100 most-cited articles had only 8 articles that appeared on both lists. Compared to the most cited studies, the top 100 AAS articles had more prospective studies (32.3% vs 28.2%), fewer retrospective studies (30.4% vs 37.9%), and more review articles (14.7% vs 9.7%) (Table 2). Additionally, the top 100 AAS articles comprised more article categories with several additional literature genres: books, biomechanics, and opinion articles. The top 100 most cited articles were published across 28 unique journals, while the top 100 articles by AAS score were among 48 different journals. Among all countries contributing Twitter mentions, the 3 countries with the most cervical spine posts included the United States (23.3%), the United Kingdom (10.3%), and Spain (5.5%, Figure 1).

## DISCUSSION

Although citation rates and impact factors have traditionally been used to assess the influence of academic publications, social media outlets, such as Twitter and Facebook, are playing an increasing role

in the dissemination of medical information. In order to take the influence of these “less formal” sources into account, innovative measures such as the Altmetric score have been developed. Altmetric rankings for general spine-related literature have previously been assessed by Parrish et al.<sup>12</sup> However, while lower back pain and problems related to the lumbar spine may be considered a relatively “mainstream” topic in modern medicine, the cervical spine may represent more of a specialized or “niche” subset of literature with a potentially narrower scope of both contributors and readers. Our analysis of literature related to the cervical spine revealed a number of differences based on which metric was used to identify articles.

In terms of the articles returned by our search of the Altmetric database, *Spine*, *European Spine Journal*, and *The Spine Journal* published the most articles related to the cervical spine. In their broader review of the Altmetric database for articles related to the spine in general, Parrish et al identified the same 3 journals as the most prolific contributors of spine-related literature.<sup>12</sup> The tendency of relevant articles to be published in spine-specific journals, rather than general medical or orthopedic publications, highlights the specificity of cervical spine surgery. It also further emphasizes the importance of understanding how spine-related literature is disseminated to the general public, especially given the relatively narrow readership of many such journals. Interestingly, only one of the top cervical spine research publishers score among the top AAS scores, with top scores belonging to *Journal of Neurosurgery: Spine*, *Spine*, and the *Journal of Manipulative & Physiological Therapeutics*. Wang et al performed a similar analysis of articles published in neurosurgical journals and determined that the *Journal of Neurosurgery* had the most publications among their list of the top 100 articles ranked by AAS score.

**Table 2.** Top 25 cervical spine literature ranked by Altmetric Attention Score (AAS).

Rank	AAS	Authors	Title	Journal or Book	Year	DOI
1	1510	Nakashima H, Yukawa Y, Suda K, Yamagata M, Ueta T, Kato F	Abnormal findings on magnetic resonance images of the cervical spines in 1211 asymptomatic subjects	<i>Spine</i>	2015	10.1097/brs.0000000000000775
2	688	Page PS, Wei Z, Brooks NP	Motorcycle helmets and cervical spine injuries: a 5year experience at a Level one trauma center	<i>Journal of Neurosurgery: Spine</i>	2018	10.3171/2017.7.spine17540
3	564	Mai HT, Burgmeier RJ, Mitchell SM, et al	Does the level of cervical disc herniation surgery affect performance-based outcomes in national football league athletes?	<i>Spine</i>	2016	10.1097/brs.0000000000001868
4	409	Gornet MF, Lanman TH, Burkus JK, et al	Cervical disc arthroplasty with the Prestige LP disc vs anterior cervical discectomy and fusion, at two levels: results of a prospective, multicenter randomized controlled clinical trial at 24 months	<i>Journal of Neurosurgery: Spine</i>	2017	10.3171/2016.10.spine16264
5	406	Burkus JK	Early outcomes of anterior cervical discectomy and fusion using a porous PEEK interbody fusion device	<i>Journal of Neurosurgery: Spine</i>	2018	10.4172/2325-9701.1000295
6	398	Radcliff K, Davis RJ, Hisey MS, et al	Long-term evaluation of cervical disc arthroplasty with the mobi-c© cervical disc: a randomized, prospective, multicenter clinical trial with seven-year follow-up	<i>International Journal of Spine Surgery</i>	2017	10.14444/4031
7	387	Sasso RC, Phillips FM, Guyer RD, et al	M6-C artificial cervical disc: two-year follow-up at five IDE investigation centers	<i>Spine Journal</i>	2017	10.1016/j.spinee.2017.07.151
8	381	Siemionow KB, Glowka P, Blok RJ, et al	Perioperative complications in patients treated with posterior cervical fusion and bilateral cages	<i>Journal of Craniovertebral Junction &amp; Spine</i>	2017	10.4103/jcvjs.jcvjs_61_17
9	378	Bou Monsef JN, Siemionow KB.	Multilevel cervical laminectomy and fusion with posterior cervical cages	<i>Journal of Craniovertebral Junction &amp; Spine</i>	2017	10.4103/jcvjs.jcvjs_69_17
10	378	Hansraj KK	Assessment of stresses in the cervical spine caused by posture and position of the head.	<i>Surgical Technology International</i>	2014	
11	293	Diebo BG, Challier V, Henry JK, et al	Predicting cervical alignment required to maintain horizontal gaze based on global spinal alignment	<i>Spine</i>	2016	10.1097/brs.0000000000001698
12	218	Benzel EC, Connolly PJ, eds	NA	<i>The Cervical Spine</i>	2017	NA
13	186	Arnold PM, Sasso RC, Janssen ME, et al	Efficacy of i-factor bone graft vs autograft in anterior cervical discectomy and fusion	<i>Spine</i>	2016	10.1097/brs.0000000000001466
14	183	Davis RJ, Kim KD, Hisey MS, et al	Cervical total disc replacement with the Mobi-C cervical artificial disc compared with anterior discectomy and fusion for treatment of 2-level symptomatic degenerative disc disease: a prospective, randomized, controlled multicenter clinical trial	<i>Journal of Neurosurgery: Spine</i>	2013	10.3171/2013.6.spine12527
15	178	Martin MJ, Bush LD, Inaba K, et al; WTA C-Spine Study Group	Cervical spine evaluation and clearance in the intoxicated patient	<i>Journal of Trauma and Acute Care Surgery</i>	2017	10.1097/ta.0000000000001650
16	161	Khan AD, Liebscher SC, Reiser HC, et al	Clearing the cervical spine in patients with distracting injuries	<i>Journal of Trauma and Acute Care Surgery</i>	2019	10.1097/ta.0000000000002063
17	139	Patel MB, Humble SS, Cullinane DC, et al	Cervical spine collar clearance in the obtunded adult blunt trauma patient	<i>Journal of Trauma and Acute Care Surgery</i>	2015	10.1097/ta.0000000000000503
18	125	Streifer M, Brown AM, Porfido T, Anderson EZ, Buckman JF, Esopenko C.	The potential role of the cervical spine in sports-related concussion: clinical perspectives and considerations for risk reduction	<i>Journal of Orthopaedic and Sports Physical Therapy</i>	2019	10.2519/jospt.2019.8582
19	124	McAnany SJ, Rhee JM, Baird EO, et al	Observed patterns of cervical radiculopathy: how often do they differ from a standard, "Netter diagram" distribution?	<i>Spine Journal</i>	2019	10.1016/j.spinee.2018.08.002



Table 2. Continued.

Rank	AAS	Authors	Title	Journal or Book	Year	DOI
20	107	Vanichkachorn J, Peppers T, Bullard D, Stanley SK, Linovitz RJ, Ryaby JT	A prospective clinical and radiographic 12 month outcome study of patients undergoing single-level anterior cervical discectomy and fusion for symptomatic cervical degenerative disc disease utilizing a novel viable allogeneic, cancellous, bone matrix (trinity evolution™) with a comparison to historical controls	<i>European Spine Journal</i>	2016	10.1007/s00586-016-4414-7
21	102	Cuéllar JM, Lanman TH, Rasouli A	The safety of single and multilevel cervical total disc replacement in ambulatory surgery centers	<i>Spine</i>	2020	10.1097/brs.0000000000003307
22	96	Hutting N, Kerry R, Coppieters MW, Scholten-Peeters GGM	Considerations to improve the safety of cervical spine manual therapy	<i>Musculoskeletal Science and Practice</i>	2018	10.1016/j.msksp.2017.11.003
23	90	Rose MK, Rosal LM, Gonzalez RP, et al	Clinical clearance of the cervical spine in patients with distracting injuries: It is time to dispel the myth.	<i>Journal of Trauma and Acute Care Surgery</i>	2012	10.1097/ta.0b013e3182587634
24	86	Luedtke K, May A	Stratifying migraine patients based on dynamic pain provocation over the upper cervical spine	<i>The Journal of Headache and Pain</i>	2017	10.1186/s10194-017-0808-0
25	84	Radcliff K, Coric D, Albert T	Five-year clinical results of cervical total disc replacement compared with anterior discectomy and fusion for treatment of 2-level symptomatic degenerative disc disease: a prospective, randomized, controlled, multicenter investigational device exemption clinical trial	<i>Journal of Neurosurgery: Spine</i>	2016	10.3171/2015.12.spine15824

Abbreviations: DOI, digital object identifiers; NA, not applicable.

Twitter, Facebook, and web-based news sources contributed the most social media mentions per article, with Twitter in particular demonstrating by far the highest rate of mentions at 4.4, compared to 0.5 and 0.3 for Facebook and news sources, respectively. Parrish et

al similarly found that Twitter was especially influential in contributing to the Altmetric score of spine-related articles.<sup>12</sup> Studies have demonstrated that a number of social media campaigns by academic journals and groups have been successful in increasing the readership

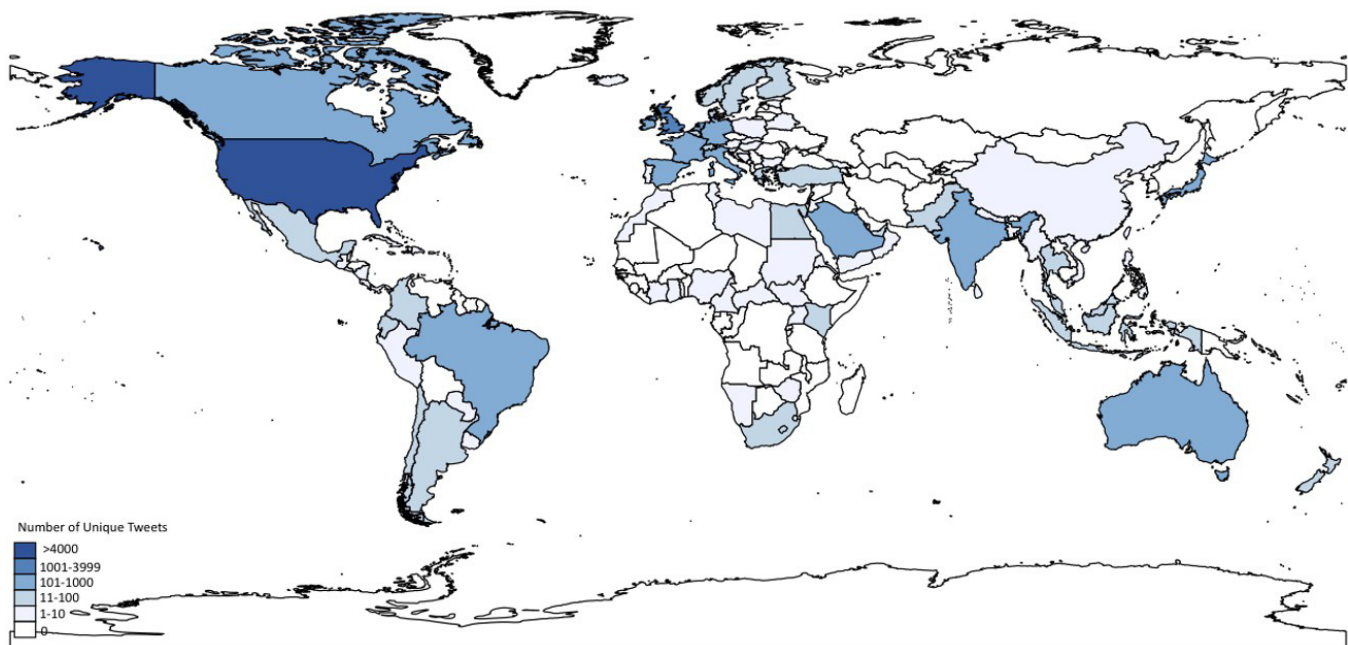


Figure. Worldwide number of unique cervical spine tweets by country.

of their articles.<sup>16,17</sup> Furthermore, an observational study of the top 50 trauma and orthopedic surgery journals, ranked by 2016 impact factor, demonstrated significant correlations between traditional measures of academic influence (ie, impact factor) and social media activity, particularly in terms of Twitter engagement by journals, Twitter followers and mentions on Twitter.<sup>18</sup>

A number of previous studies have demonstrated relationships between Altmetric scores and more traditional metrics such as citation count.<sup>18–20</sup> Twitter mentions, in particular, are directly correlated with citation count, though they accumulate at a significantly higher rate than citations.<sup>18,19</sup> In a study of radiation oncology literature, Paradis et al found that not only was a Twitter activity associated with the number of times an article was cited but also that articles with a Twitter “buzz” of 10 or more tweets prior to publication had 3.6 more citations than those that did not.<sup>21</sup>

However, only 8 of the articles identified by our analysis overlapped between the top 100 identified by AAS and the top 100 most cited articles. This discrepancy underlines the difference in the articles that are highlighted and elevated by “alternative” sources, such as social media, compared to those that are frequently cited by other peer-reviewed, academic publications. Interestingly, a systematic review of orthopedic randomized clinical trials demonstrated that higher numbers of social media mentions (mostly Twitter) were associated with less risk of bias, in addition to higher journal impact factor and higher author h-index values.<sup>19</sup>

Social media can significantly impact the type and content of medical information that is readily available to the public. An analysis of colorectal cancer information available on Twitter by Park et al determined that although medical professionals and institutions produced a relatively low proportion of total tweets on the topic (2.0% and 0.6%), 84.5 % of the information posted was medically accurate.<sup>22</sup> Providing further hope for the information on social media, Park et al found that the most frequently retweeted tweets were significantly more accurate than randomly selected tweets. Conversely, a study of the reliability of health information disseminated on Twitter found that over half of the Arabic language, health-related tweets posted by professionals over a 5-day span provided information that was not true.<sup>23</sup>

In addition to differences in the content of the articles prioritized by social media and traditional citation rates, variation also exists with regard to the *type* of publications that are prioritized. Our analysis of cervical spine literature revealed that the top AAS articles included

more prospective studies and qualitative review articles, while the most cited articles contained more retrospective studies and systematic reviews. This highlights an interesting association given that prospective studies or randomized controlled trials are perceived as a higher level and preferred methodology of research. Similar to our findings, studies involving journals from other medical fields have reported that over 25% of the research conducted utilized the retrospective chart review research design.<sup>24</sup> It must be noted that with the appropriate design, retrospective cohort studies may offer substantial validity and reliability as well.<sup>25</sup> With AAS promoting a higher level of research methodology as compared to citation frequency, this suggests that Altmetric scores may facilitate the promotion of research that is more generalizable and reliable. As medicine continues to become globalized and increasingly connected, understanding regional trends in literature contribution and readership is more important than ever. In their 2016 study of “The 100 most Influential Articles in Cervical Spine Surgery”, Skovrlj et al list the United States, Japan, and Canada as the origin of the most articles in their top 100 most-cited list, with 65, 16, and 6 top 100 articles, respectively.<sup>6</sup> The United States has consistently dominated in terms of publication volume and citation rate, both for the cervical spine and spine literature in general, with Japan, China, Germany, and Canada frequently cited as other major contributors.<sup>14,26–28</sup> Additionally, research productivity has been tied to economic status, with high-income countries producing the vast majority of spine-related publications, followed by middle-income, and distantly by low-income countries.<sup>14</sup> While this economic inequality in research productivity may not be surprising, it provides further reason to understand less traditional channels for the dissemination of spine-related literature at the global level, including social media outlets such as Twitter.

Our analysis of the Altmetric database revealed that the United States, the United Kingdom, and Spain contributed the most Twitter mentions of literature related to the cervical spine. Given its well-documented role in producing spine-related literature, it is unsurprising that the United States would also be a leader in terms of social media activity related to the cervical spine. Interestingly, however the trends we observed in other countries tweeting about cervical spine literature are consistent neither with previous data regarding regional contributions to spine literature nor with trends in Twitter usage by country. As of July 2020, the United States had by far the largest Twitter audience at 62.6 million users and Japan the second most at 49.1 million.<sup>29</sup> However, the United Kingdom was fifth in Twitter participation at 15.3 million, and Spain was

13th with only 7.1 million users. Furthermore, while the United States and the United Kingdom are both predominantly English-speaking countries, Spain is not. A recent review of health-related posts on Twitter indicated that the average writing level of these tweets was equivalent to approximately a 6- to 9-year-old level, which is substantially lower than the reading level of the average user.<sup>30</sup> This relatively simple level of writing may explain the accessibility of Twitter posts even if they are not written in the user's first language. Our results regarding global Twitter mentions of cervical spine literature are especially interesting to consider in this context, since they highlight a unique proclivity for social media-based dissemination of cervical spine literature in the United Kingdom and Spain that do not appear to be based solely on either the research productivity or the Twitter engagement of these countries.

Social media facilitates the rapid dissemination of research articles at a large scale.<sup>23</sup> Possible pitfalls associated with lower barriers for dissemination include misinterpretation of research findings and increased circulation of pseudoscience.<sup>23</sup> Within the context of cervical spine literature, our analysis noted that top AAS articles included more prospective studies and qualitative reviews vs retrospective studies, with AAS scores correlating with research that is generalizable, valid, and reliable. However, there was a noted disconnect between the top 100 most-cited articles and the top 100 articles by AAS score. The findings of our study would suggest social media can be a tool that can promote increased awareness of quality cervical spine literature but would caution readers to be aware that articles with higher AAS scores may tend to overrepresent studies of specific content type and methodological method when compared with peer-reviewed journals. Another pitfall for consumers of research spread via social media to navigate is to ensure that study findings commented on by social media participants correctly represent the article shared. Without peer review, self-policing is critical to combat the spread of pseudoscience.

### Limitations

While our analysis of global social media trends in cervical spine literature provides valuable information for clinicians and researchers, it is not without limitations. First, our methodology relied heavily upon the Altmetric database. Although it has been accepted by many as a valid indication of literature's public influence, parallel use of additional metrics or direct analysis of social media data may have added increased granularity and validity to our analysis. Additionally, while we did report global trends in social media mentions, we were able to assess neither how

these trends related to article content or clinical implementation nor the language in which tweets were written. The role of social media engagement is a relatively novel topic in the field of spine surgery and a number of possibilities exist to expand upon this research.

## CONCLUSION

*Spine*, *European Spine Journal*, and *The Spine Journal* were the most frequent publishers of articles related to the cervical spine and the *Journal of Neurosurgery: Spine*, *Spine*, and the *Journal of Manipulative & Physiological Therapeutics* had the highest overall AAS scores. Twitter was by far the largest source of cervical spine literature social media mentions. There was little overlap between the top 100 articles ranked by AAS and citation rates and article categories varied substantially between these rankings. Geographically, the largest sources of Twitter posts related to the cervical spine were the United States, the United Kingdom, and Spain. This work highlights the trends in social media coverage of cervical spine literature and how these trends differ from conventional measures of literature influence.

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