World Neurosurgery: X 23 (2024) 100385

Contents lists available at ScienceDirect

World Neurosurgery: X

journal homepage: www.journals.elsevier.com/world-neurosurgery-x

Original article

Most influential women neurosurgeons on Twitter

Vid Raturi [a], Johnny Delashaw [a,b], Aaron Dumont [a,b], Arthur Wang [a,b,*]

[a] Tulane University School of Medicine, New Orleans, LA, USA
[b] Department of Neurological Surgery, New Orleans, LA, USA

ARTICLE INFO

Keywords:
Women
Twitter
Social media
Influential

ABSTRACT

Background: Social media platforms can increase gender diversity and foster community within the neurosurgical field. Women have been historically underrepresented in neurosurgery. The purpose of this study is to compile a list of women neurosurgeons on Twitter according to their social media influence and identify whether social media influence correlates with academic productivity.

Methods: Women neurosurgeons (post-residency) in the United States who have Twitter accounts were obtained via the Women in Neurosurgery Twitter account and individuals who used the hashtag: #womeninneurosurgery (n= 50). Social media influence (followers, original posts, likes, retweets) was extracted through Popsters social media analytics platform for each of the accounts from January 1st, 2023 to June 30th, 2023. The efficiency metric standardized retweets for follower count, as well as number of posts. Academic H-index scores were ascertained via SCOPUS. 3 lists were created based off the efficiency metric, follower count, and average likes per post.

Results: The relationship between the efficiency metric (average retweets per post per follower) and H-index was not significant at level of $p < 0.05$, whereas the relationships between follower count and H-index, and average likes per posts and H-index were significant at $p < 0.05$.

Conclusion: The significant positive association found between H-index and average likes, as well as H-index and follower count demonstrates that social media influence and academic productivity/influence may go hand in hand. The lists of women neurosurgeons may serve as a guide for individuals interested in following women neurosurgeons on Twitter. Additionally, this would aid in fostering a community supportive of women neurosurgeons. Further, this may also inform individuals who would like to grow their presence on social media on how to build their following.

1. Introduction

Pew Research Center estimates that 70 % of Americans utilized social media platforms in 2021 and 23 % were active on Twitter.[1] The use of social media within the field of neurosurgery has exponentially increased since 2016.[2–4]

In the neurosurgical community, social media has risen and continues to rise as a popular tool for education, awareness, patient care, and community building. It has transformed the capacities of physicians to connect with patients, students, colleagues, leaders, and community members not only around the nation but also around the world. Social media provides the unique benefit of disseminating information in a concise manner with a large audience in the matter of minutes.[5]

According to the Association of American Medical Colleges in 2021, although 55.5 % of medical students are women, women only made up 9.6 % of practicing neurosurgeons in the United States and 20.5 % of neurosurgical residents.[6–8] There is a long history of women being underrepresented in neurosurgery. However, they have been making steady progress towards increasing gender diversity in neurosurgery.[9] It is speculated that these gender inequities exist due to difficulties in recruiting and retaining women in this field. Suspected barriers that may dissuade women from entering neurosurgery are implicit and explicit gender discriminatory practices, extensive time commitment during years critical to family planning and fertility, the demanding nature of the field, perceived work-life sacrifices, stereotypes, male dominance, as well as lack of women guidance, representation, and mentorship due to the limited number of women neurosurgeons.[10–13]

Social media can be a tool to address the gender gap in neurosurgery. It can highlight the experiences of women neurosurgeons, both the rewards and challenges, in order to inspire other women to enter the field.

* Corresponding author. Tulane University School of Medicine, New Orleans, LA, USA.
E-mail address: awang15@tulane.edu (A. Wang).

https://doi.org/10.1016/j.wnsx.2024.100385
Received 27 December 2023; Accepted 22 April 2024
Available online 24 April 2024

Due to social media's power to reach so many people this can also increase mentorship for women interested in the field. Seeing positive role-models in neurosurgery who look like women medical students and individuals interested in medicine can make a big difference in the specialty decision-making process. This can be especially true for students who may not have a woman neurosurgeon at their home institution. Further, social media can not only provide mentorship, but also expose individuals to neurosurgery earlier on, create a network of professionals and students interested in the field, as well as unite individuals. Not only can this positively impact women neurosurgeons, but the neurosurgery community and the patient community as a whole by promoting collaboration, as well as knowledge and idea sharing.[12,14]

This highlights that it may be helpful for individuals to know which women neurosurgeons are the most influential and active on social media platforms as it can inform them on who to follow. Therefore, in this study, we identify the top 50 women neurosurgeons who are the most active on Twitter was chosen as the social media platform for this because by several metrics, Twitter provides demographic information on the individuals identified, as well as conduct correlational analysis between social media influence using several metrics, and academic influence, represented by their "H-index" scores. Twitter and H-index were chosen to build off a previous paper that calculated the top 100 neurosurgery social media influencers on Twitter.[15] This is the first study to elucidate the top 50 most influential women neurosurgeons on Twitter.

2. Methods

Women neurosurgeons who have Twitter accounts were obtained in July 2023 by going through the Women in Neurosurgery (WINS) Twitter account's (@WINSneurosurge1) follower list as well as searching for individuals who used the hashtag: #womeninneurosurgery. The #womeninneurosurgery was used to identify women neurosurgeons as other studies have used similar criteria for their searches.[16] In an effort to account for women neurosurgeons who did not use this hashtag, researchers went through the follower list of the WINS twitter account. WINS serves as an advocacy and networking platform for women in neurosurgery.[11] They are an organization that is well known in the global neurosurgical community and host events for women neurosurgeons at many national neurosurgical conferences. Due to WINS' presence among the neurosurgical community, it was hypothesized that many women neurosurgeons who are on Twitter would follow the WINS Twitter account. Since people do not necessarily use their full names for their Twitter account handles, this was the best way the researchers proposed to search for women neurosurgeons.

Men neurosurgeons were not included in this study as the purpose of the study was to identify women neurosurgeons on Twitter due to the underrepresentation of women in neurosurgery. The previous study by Riccio et al included men in their study, and this current study is meant to build off that one by specifically focusing on women. 8 % of the individuals included in the study by Riccio et al of the "Top 100 Social Media Influencers in Neurosurgery of Twitter" were post-residency women neurosurgeons in the United States.[15] Therefore, in order to get a better picture of the social media influence of post-residency women neurosurgeons in the United States, men, non-neurosurgeons, neurosurgeons from outside of the United States, and residents, were not included.

Subspecialty, institution, and location of practice were confirmed using their Twitter biographies, the American Board of Neurological Surgery and cross referenced with their institutional or practice's website.

Social media influence was extracted for each of the accounts through Popsters (www.popsters.com), a social media analytics platform that allows us to extract engagement data. The information extracted included the total number of followers, the total posts, number of original posts (not including posts they retweeted), the total likes of original posts, and the total retweets of original posts from January 1st, 2023, to June 30th, 2023. The number of total posts from January 1st to June 30th, as well as total likes of original posts and total retweets of original posts during this time-period was recorded as a measure of their current activity on Twitter. This data was then used to determine average likes per posts, average retweets per post, and average retweets per post per follower (efficiency metric, EF). The efficiency metric standardized the data to account for follower count, as well as number of posts. It served as an indicator that for every follower how many retweets for each post does each neurosurgeon have. Retweets were chosen for the efficiency metric as it is a higher engagement than a like as someone who retweeted the post from the author felt the need to reshare it on their page. Academic H-index scores were ascertained via SCOPUS (Reed Elsevier, London, UK). Being one of the largest published works databases, this measure of academic influence is used to explain the productivity (number of published works) and impact (number of times each work is cited) of the published works a researcher produces. SCOPUS is especially advantageous due to its commitment to high quality data, while also encompassing a broad variety of published documents in a majority of journals for its high accuracy algorithm to calculate dependable H-index scores.

Data analyses and figures were performed/generated using Microsoft Excel (Seattle, WA, US). The Pearson correlation coefficient (r) was calculated to compare two sets of data. $p < 0.05$ was considered statistically significant. Descriptive statistics were used for summarizing the data.

3. Results

In this section, there are several rankings provided on various categories. There were 50 women neurosurgeons identified who had Twitter accounts. The top 45 women neurosurgeons on Twitter ranked by the efficiency metric of retweets per post per follower are presented in Table 1.

Ranking for the 45th position was tied among 5 neurosurgeons they did not have any authored posts from January 1st 2023 to June 30th 2023. Therefore, their efficiency metrics were unable to be calculated. The average efficiency score was 0.002205523156, with the range being from 0 to 0.01746724891. A rank list by number of followers was gathered for all 50 neurosurgeons. The maximum number of followers was 11,500 and the minimum number of followers was 30. The average number of followers is 1766.64 (Table 2).

After this rank list was generated, a series of analyses was performed. The relationship between the efficiency metrics of the 44 neurosurgeons whose efficiency metrics were able to be calculated and their H-index scores was determined (Fig. 1). The p-value of the correlation coefficient for the relationship between efficiency metric and H-index scores is 0.3966 ($p < 0.05$). The relationship between follower count and H-index for all 50 neurosurgeons was also analyzed (Fig. 2). For this, the correlation coefficient's p-value is 0.002801 ($p < 0.05$).

Next, a list of women neurosurgeons ranked by likes per original post was created. The likes per original post were able to be calculated for 44 individuals. For the 6 individuals who were tied for the 45th place, likes per original post was unable to be calculated due to lack of posts in the given time period that was analyzed. The average number of likes per original posts across all of the individuals was 25.49 with the range being 1 to 306.83 (Table 3). The p-value associated with the correlation coefficient for the relationship between averages likes per post from January 1st, 2023–June 30th, 2023 and H-index was 0.023938 ($p < 0.05$) (Fig. 3).

Out of the 50 neurosurgeons, 38 (76 %) are Diplomates and 12 (24 %) are Candidates distinguished by the American Board of Neurological Surgery (Fig. 4). Diplomates are individuals who have gotten board certification and candidates are tracking towards board certification.

22 % of the neurosurgeons have a subspecialization in Pediatrics, 18 % in Spine, 16 % in Skull Base, 12 % in Vascular, 12 % in Functional, 8 %

Table 1
Top 45 Women Neurosurgeons on Twitter ranked by the efficiency metric (retweets per post per follower) from June 1st to January 30th, 2023.

Ranking by Average Retweets per Post per Follower (Efficiency Metric)				
Rank	Name	Twitter Handle	Retweets per post per follower (efficiency metric)	H-Index
1	Neena Marupudi	@NeenaMarupudi	0.01746724891	9
2	Christina Jackson	@dr_CJackson	0.006884681583	13
3	Betsy Grunch	@ladyspinedoc	0.005198978421	5
4	Liesl Close	@closeliesl	0.004761904762	9
5	Kimberly Kicielinski	@doctorKNSGY	0.003909026297	9
6	Maria Peris-Celda	@periscelda	0.003780487805	15
7	Laura Ngwenya	@surgeonscience	0.003740468997	18
8	Doris Wang	@doriswanglab	0.003681746536	28
9	Nnenna Mbabuike	@NSMbabuike_MD	0.003315649867	1
10	Christina H Wright	@chuang84	0.003164556962	10
11	Jennifer Sweet	@JSweetMD	0.002906976744	19
12	Megan Jack	@meganjackmdphd	0.002598457166	1
13	Sharona Ben-Haim	@SBenHaimMD	0.002430005283	14
14	Kimberly Bojanowski Hoang	@kimberlybhoang	0.002374169041	10
15	Carrie Muh	@Doc_Muh	0.002302379125	14
16	Sheri Dewan	@drsheridewan	0.00227447687	3
17	Rosalind Lai	@rosalind_lai	0.002252252252	11
18	Jennifer Strahle	@strahleMD	0.002230778633	23
19	Olabisi Sanusi	@MdOlabisi	0.001954215522	3
20	Gail Rosseau	@grosseaumd	0.001662971175	22
21	Nicole Bentley	@jnbmd	0.001496259352	12
22	Smruti Patel	@smrutipatelmd	0.001386248416	10
23	Ellen Air	@nsurgchick	0.001383275923	24
24	Christine K Lee	@CKLeeMD	0.001164483261	10
25	Uzma Samadani	@DrSamadani	0.001143463505	27
26	Melanie Hayden Gephart	@HaydenGephartMD	0.001117827275	21
27	Laura Stone McGuire	@stonemcguire	0.0009883611949	7
28	Sandi Lam	@sandi_lam	0.000944442519	28
29	Stavropoula Tjoumakaris	@StavTjoumakaris	0.0009338468355	45
30	Angela M Richardson	@angelaMRichard1	0.000895300177	8
31	Ann Stroink	@neurosurgeryRE	0.0008222932846	10
32	Rushna Ali	@rushnaali6	0.0008025540101	10
33	Krystal Tomei	@KLTomei	0.0007942811755	13
34	Heather J McCrea	@HMcCreaMDPhD	0.0006858710562	14
35	Martina Stippler	@martinastippler	0.0006533921017	16
36	Analiz Rodriguez	@arodmdphd	0.0006203473945	19
37	Kathryn Ko	@DrKathrynKo	0.0005188451988	10
38	Lola Chambless	@lola_chambless	0.0004577161968	26
39	Cara Sedney	@SNeurosurgS	0.0003743315508	11
40	Erika Petersen	@erikapetersenMD	0.0003737039629	2
41	Suzanne Tharin	@spinetharin	0.000324792493	10
42	Maya Babu	@mayababuMD	0.000269950032	14
43	Rima Rindler	@rimarindler	0	10
44	Lara Massie	@lwm208	0	6
45	Kristin Weaver	@kweaverMDPhD	–	8
45	Rupa Juthani	@rjuthani	–	8
45	Alexandra Paul	@alexandrapaulMD	–	11
45	Corrina Zygourakis	@DrZygourakis	–	24
45	Ann Marie Flannery	@aflannery516	–	23
45	Carolyn Quinsey	@carolynquinsey	–	7

in Neuro-oncology, 8 % in Neurocritical/Trauma, and 4 % in General (Fig. 5). 10 % of these neurosurgeons are in private practice whereas 90 % are practicing academic medicine as they are associated with academic institutions (Fig. 6).

Out of the 45 neurosurgeons who practiced academic medicine, 4 of them are associated with Stanford, whereas 2 are associated with each of the following institutions: University of Cincinnati, University of Arkansas Medical Sciences, University of California San Francisco, Oregon Health and Sciences University, Northwestern University, Mayo Clinic, and Case Western University. 27 individuals were the only women neurosurgeons from their institution on Twitter (Fig. 7).

Out of the 50 women neurosurgeons, 17 are located in the Midwest (34 %), 14 in the South (28 %), 10 in the West (20 %), and 9 in the Northeast (18 %) (Fig. 8). California has the highest number of women neurosurgeons on Twitter (7, 15 %), followed by New York (5, 10 %), Ohio (5, 10 %), Illinois (4, 8 %), Minnesota (3, 6 %), Michigan (3, 6 %), and Pennsylvania (3, 6 %). The 50 women neurosurgeons on Twitter in general practiced in 23 out of the 50 states in the United States (Fig. 9).

4. Discussion

Social media has impacted the neurosurgery field and continues to grow as a prominent tool to disperse information and education pertinent to the field.[17] Several individuals across the globe have access to a mobile device within the past decade due to the rise of more affordable and accessible internet. Moreover, individuals on the internet, tend to spend most of their time on social media platforms. This rings especially true for the younger generations.[18] Research has shown that women physicians and surgeons are more likely to utilize social media platforms.[19]

Globally, more women are entering the field of neurosurgery.[20,21] Organizations such as "Women in Neurosurgery (WINS)" have been making strides in the neurosurgical community to increase representation and gender equity within the field. Their mission being to "educate, inspire, and encourage women neurosurgeons to realize their professional and personal goals, and to serve neurosurgery in addressing the issues inherent to training and maintaining a diverse and balanced workforce." They have been specifically harnessing the power of social media to share women neurosurgeon's experiences, provide mentorship opportunities, highlight women neurosurgeons' accomplishments, as well as foster a supportive and inclusive community of attendings, residents, and medical students, both men and women.[13]

Even in 2023, we are witnessing women's firsts. Tamia Potter, a member of WINS, made history as the first Black woman neurosurgery resident at Vanderbilt University. Social media has allowed her accomplishment to reach millions of people according to her tagged Instagram views and Twitter post insights. Over 51 separate accounts shared her achievement on Instagram and over 63 on Twitter. Her accomplishment has perpetuated a butterfly effect, inspiring individuals across the world, from all walks of life. This dissemination of information wouldn't have been possible without social media platforms, which

Table 2
Ranking by number of followers.

Ranking by Number of Followers				
Rank	Name	Twitter Handle	Number of Followers	H-index
1	Lola Chambless	@lola_chambless	11500	26
2	Analiz Rodriguez	@arodmdphd	6448	19
3	Doris Wang	@doriswanglab	4723	28
4	Stavropoula Tjoumakaris	@StavTjoumakaris	3965	45
5	Martina Stippler	@martinastippler	3473	16
6	Maya Babu	@mayababuMD	3266	14
7	Erika Petersen	@erikapetersenMD	3184	2
8	Uzma Samadani	@DrSamadani	2803	27
9	Suzanne Tharin	@spinetharin	2771	10
10	Sandi Lam	@sandi_lam	2684	28
11	Angela M Richardson	@angelaMRichard1	2616	8
12	Carrie Muh	@Doc_Muh	2606	14
13	Kathryn Ko	@DrKathrynKo	2453	10
14	Betsy Grunch	@ladyspinedoc	2429	5
15	Ann Stroink	@neurosurgeryRE	1990	10
16	Laura Stone McGuire	@stonemcguire	1893	7
17	Jennifer Strahle	@strahleMD	1818	23
18	Rushna Ali	@rushnaali6	1747	10
19	Christina Jackson	@dr_CJackson	1743	13
20	Cara Sedney	@SNeurosurgS	1700	11
21	Maria Peris-Celda	@periscelda	1640	15
22	Ellen Air	@nsurgchick	1603	24
23	Nnenna Mbabuike	@NSMbabuike_MD	1508	1
24	Carolyn Quinsey	@CarolynQuinsey	1444	7
25	Sharona Ben-Haim	@SBenHaimMD	1262	14
26	Krystal Tomei	@KLTomei	1259	13
27	Gail Rosseau	@grosseaumd	1230	22
28	Olabisi Sanusi	@MdOlabisi	1194	3
29	Corinna Zygourakis	@DrZygourakis	1153	24
30	Melanie Hayden Gephart	@HaydenGephartMD	929	21
31	Sheri Dewan	@drsheridewan	866	3
32	Ann Marie Flannery	@aflannery516	845	23
33	Megan Jack	@meganjackmdphd	821	1
34	Kimberly Bojanowski Hoang	@kimberlybhoang	810	10
35	Smruti Patel	@smrutipatelmd	789	10
36	Christine K Lee	@CKLeeMD	687	10
37	Laura Ngwenya	@surgeonscience	662	18
38	Heather J McCrea	@HMcCreaMDPhD	486	14
39	Rosalind Lai	@rosalind_lai	444	11
40	Kimberly Kicielinski	@doctorKNSGY	402	9
41	Nicole Bentley	@jnbmd	401	12
42	Alexandra Paul	@alexandrapaulMD	375	11
43	Jennifer Sweet	@JSweetMD	344	19
44	Christina H Wright	@chuang84	316	10
45	Rima Rindler	@rimarindler	300	10
46	Neena Marupudi	@NeenaMarupudi	229	9
47	Liesl Close	@closeliesl	210	9
48	Lara Massie	@lwm208	206	6
49	Rupa Juthani	@rupa_juthaniMD	75	8
50	Kristin Weaver	@kweaverMDPhD	30	8

further highlights the importance of women neurosurgical representation on social media.

Though significant progress has been made for women in neurosurgery, there are still pervasive issues that need to be addressed regarding gender inequities and representation. Research shows that there are gender disparities for residency positions, first authorship, senior authorship, publications, grant funding, leadership positions, promotions, program director roles, and more.[22–25] Therefore, social media can be leveraged to not only educate people and share knowledge, but also to increase awareness about inequities.

Further, social media use can be harnessed to inspire others to enter the field of neurosurgery by providing insight into the field as well as mentorship. Though mentorship from anyone, regardless of gender, is

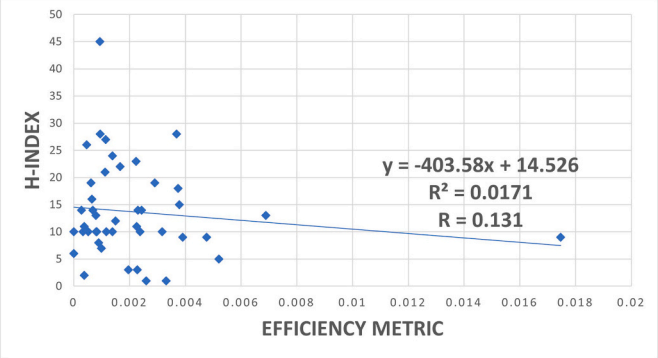

Fig. 1. Relationship between efficiency metric (retweets per post per follower) from June 1st to January 30th 2023 and H-index.

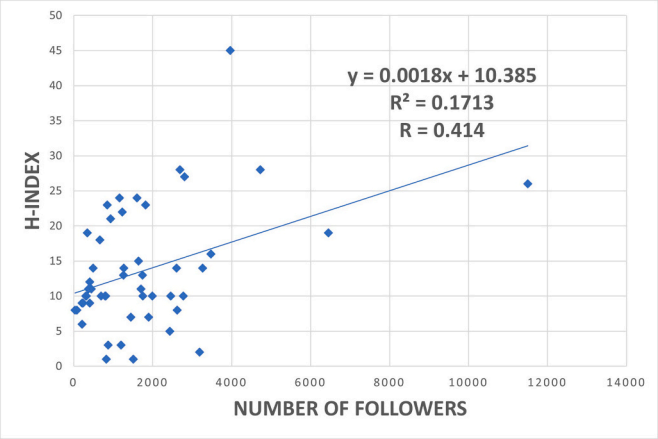

Fig. 2. Relationship between follower count and H-index.

invaluable, research has shown that having same-gender role models for women interested in professions that are male dominated increases motivation, performance, and perceived attainability of reaching professional goals.[26,27] This type of mentorship is unique because it can better represent a future self and counteract negative gender stereotypes.[28] This ultimately empowers individuals with the belief that they too can be successful in their desired field. Social media use increases accessibility for individuals to connect with same-gender role models. Subsequently, this could lead to a rise in the number of women interested in pursuing a career in neurosurgery and motivate them to work harder towards reaching their goals. If so, social media has the potential to address gender inequities in neurosurgery.

Identifying the top 50 women neurosurgery influencers across several metrics is especially relevant to the current landscape of a push to increase gender diversity in neurosurgery, as well as the significance of social media use today by healthcare professionals. Our ranking lists serve as a guide for individuals to follow women neurosurgeons who are the most impactful and engaging within the neurosurgical community. For women students interested in gaining women neurosurgeons' perspectives on neurosurgery as well as finding mentorship these lists can be extremely beneficial. For all individuals interested in supporting women neurosurgeons, learning from them, and connecting with them, these lists may be useful as well. It is important to note that the social media ranking lists are not reflective of an individual's academic prowess or neurosurgery abilities, but solely based on their social media metrics. Social media metrics are similar to the academic peer review processes as they have to go through a social vetting process by other experts in the neurosurgery field. High social media engagement scores were given to individuals who put out engaging content and interacted

Table 3
Ranking by average likes per post from January 1st to June 30th, 2023.

Ranking by Average Likes per Original Post (January 1st – June 30th 2023)				
Rank	Name	Twitter Handle	Likes per original post	H-index
1	Doris Wang	@doriswanglab	306.8333333	28
2	Betsy Grunch	@ladyspinedoc	59.19469027	5
3	Lola Chambless	@lola_chambless	55.85714286	26
4	Stavropoula Tjoumakaris	@StavTjoumakaris	39.86486486	45
5	Maria Peris-Celda	@periscelda	36.7	15
6	Carrie Muh	@Doc_Muh	35.4	14
7	Analiz Rodriguez	@arodmdphd	33.07627119	19
8	Christina Jackson	@dr_CJackson	33	13
9	Sharona Ben-Haim	@SBenHaimMD	32.73333333	14
10	Jennifer Strahle	@strahleMD	30.5	23
11	Neena Marupudi	@NeenaMarupudi	27.8	9
12	Nnenna Mbabuike	@NSMbabuike_MD	26.75	1
13	Jennifer Sweet	@JSweetMD	26	19
14	Uzma Samadani	@DrSamadani	24.12820513	27
15	Laura Ngwenya	@surgeonscience	22.38095238	18
16	Rushna Ali	@rushnaali6	20.10309278	10
17	Megan Jack	@meganjackmdphd	17.33333333	1
18	Ellen Air	@nsurgchick	16.7826087	24
19	Sheri Dewan	@drsheridewan	15.45454545	3
20	Sandi Lam	@sandi_lam	15.19767442	28
21	Melanie Hayden Gephart	@HaydenGephartMD	15.15384615	21
22	Rosalind Lai	@rosalind_lai	14.6	11
23	Kimberly Kicielinski	@doctorKNSGY	14.10714286	9
24	Martina Stippler	@martinastippler	13.96153846	16
25	Laura Stone McGuire	@stonemcguire	13.70967742	7
26	Angela M Richardson	@angelaMRichard1	13.18421053	8
27	Gail Rosseau	@grosseaumd	13.04545455	22
28	Kimberly Bojanowski Hoang	@kimberlybhoang	13	10
29	Ann Stroink	@neurosurgeryRE	11.45454545	10
30	Cara Sedney	@SNeurosurgS	11.36363636	11
31	Olabisi Sanusi	@MdOlabisi	11.33333333	3
32	Krystal Tomei	@KLTomei	10.85714286	13
33	Suzanne Tharin	@spinetharin	10.73333333	10
34	Christine K Lee	@CKLeeMD	10.2	10
35	Kathryn Ko	@DrKathrynKo	10.09090909	10
36	Erika Petersen	@erikapetersenMD	9.569620253	2
37	Nicole Bentley	@jnbmd	9.133333333	12
38	Smruti Patel	@smrutipatelmd	8.15625	10
39	Christina H Wright	@chuang84	7.625	10
40	Lara Massie	@lwm208	7	6
41	Liesl Close	@closeliesl	6.875	9
42	Maya Babu	@mayababuMD	5.355029586	14
43	Heather J McCrea	@HMcCreaMDPhD	5.166666667	14
44	Rima Rindler	@rimarindler	1	10
45	Kristin Weaver	@kweaverMDPhD	–	8
45	Rupa Juthani	@rupa_juthaniMD	–	8
45	Alexandra Paul	@alexandrapaulMD	–	11
45	Corinna Zygourakis	@DrZygourakis	–	24
45	Ann Marie Flannery	@aflannery516	–	23
45	Carolyn Quinsey	@CarolynQuinsey	–	7

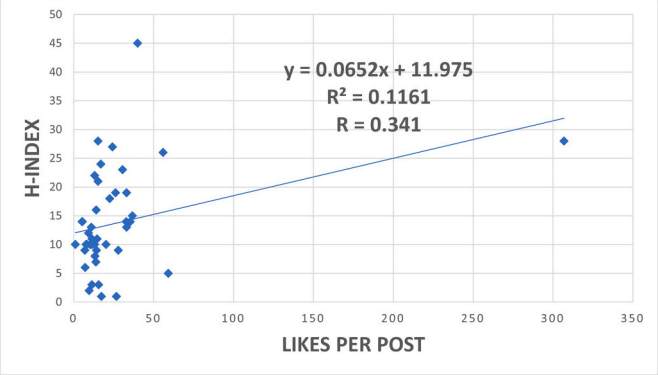

Fig. 3. Relationship between averages likes per post from January 1st to June 30th 2023 and H-index.

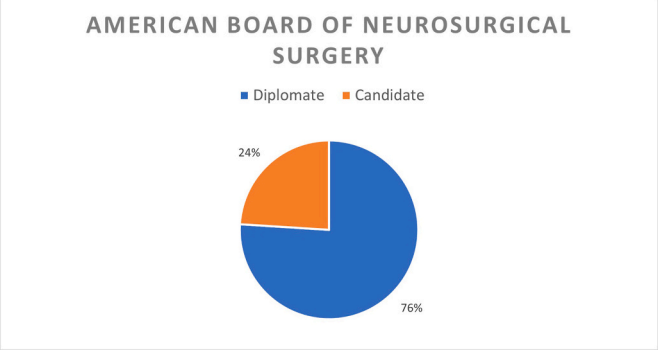

Fig. 4. American Board of Neurological Surgery Distribution for women neurosurgeons on Twitter.

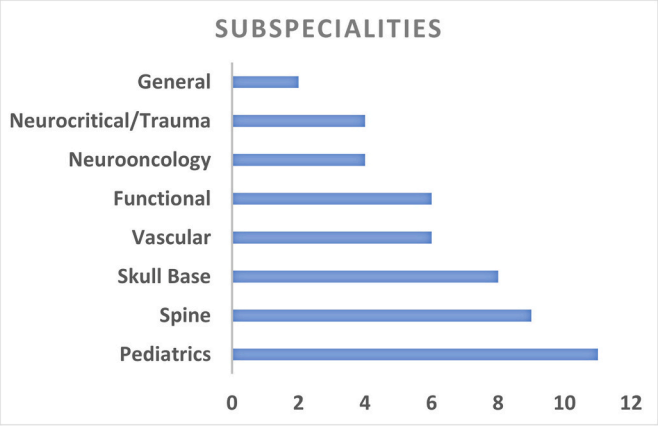

Fig. 5. Subspecialties among women neurosurgeons on Twitter.

with others in the neurosurgical community. Many of these individuals are endorsed by other board-certified neurosurgeons through followers, likes, or retweets.

Academic influence is usually measured by several factors such as number of publications, number of citations, and impact factors. These are reflected in the H-index. From our study, the relationship between the efficiency metric (average retweets per post per follower) and H-index was not significant at level of $p < 0.05$, whereas the relationships between follower count and H- index as well as average likes per posts and H-index were significant at level of $p < 0.05$. This supports that there exists a correlation between academic productivity/influence and social media influence. Both measures are reflective of an individual's ability to produce high quality engaging content that had a high impact value to other individuals. The works produced used in both academic and social media measures is in a way rated by their peers and others to assess the importance and applicability of their contributions, regardless of whether it is a manuscript or a digital post. This correlation makes sense as individuals who are well known in their fields, may be well known due to their academic prestige, which can promote others to follow and engage with their social media posts more.

The 50 women neurosurgeons were all certified or in the process of being certified through the American Board of Neurological Surgery. Among the neurosurgeons, the most common subspecialty was

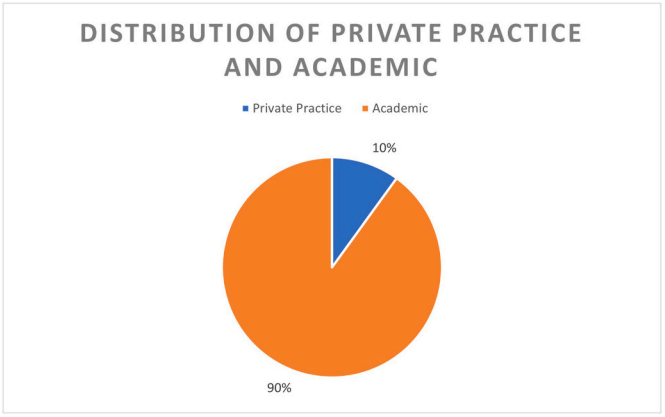

Fig. 6. Distribution of women neurosurgeons on Twitter in private practice and academic medicine.

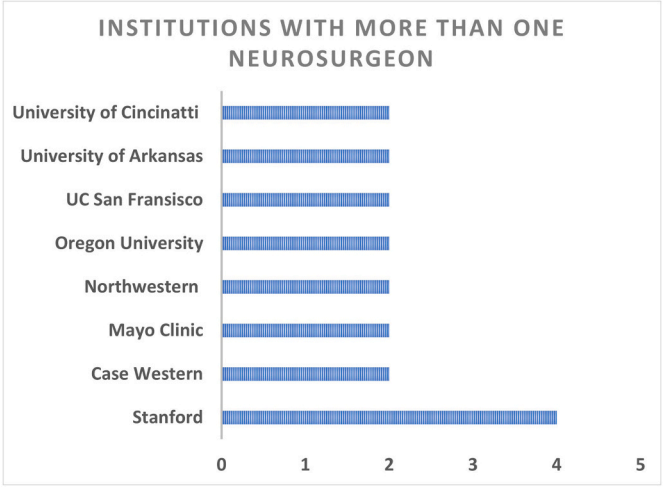

Fig. 7. Institutions with more than one women neurosurgeon on Twitter.

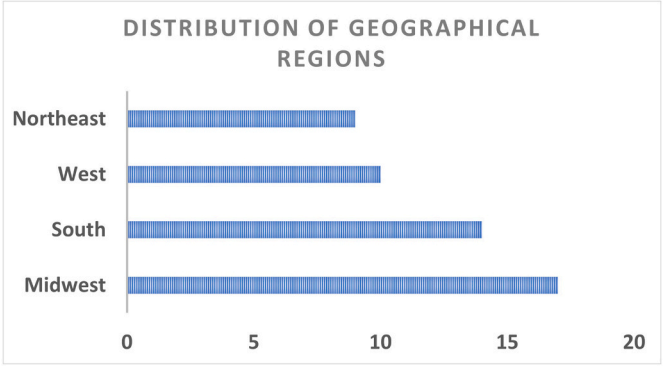

Fig. 8. Distribution of women neurosurgeon on Twitter across the geographical regions of the United States.

pediatrics. Most of the neurosurgeons practiced academic medicine. The institution that was most represented among the neurosurgeons was Stanford. The majority of neurosurgeons practiced in the Midwest, although the state which had the most women neurosurgeons on Twitter was California.

The main limitation of the study is the Popsters (www.popsters.com) social media analytics platform tool's accuracy. Though, we did randomly cross reference a sample of Popster's numbers by calculating

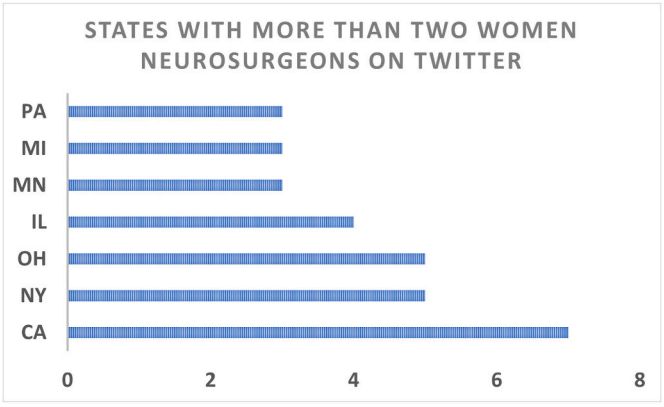

Fig. 9. States with more than Two Women Neurosurgeons on Twitter.

the measures manually. However, based on our general knowledge of neurosurgeons who are active in the field, whether it be at conferences, in the academic publishing space, or social media, this list seems accurate. Due to the study being a cross-sectional study, the results are based off one period in time. Our study does not show trends over time, instead the rankings based off social media measures taken at the time of collection (July 5th-6th, 2023). Additionally, the relationships found between social media influence and academic influence could be skewed as individuals who produced more impactful published works may be more well-known due to their academic prowess, Thus, they would have a higher follower count not necessarily due to their social media engagement strategy, but because of their reputation in field. Due to the ever-changing nature of social media, this data could potentially differ in the future. Although, due to consistent social media usage and active engagement factored into rankings, these rankings should remain relevant. Further, there may have been neurosurgery influencers that were missed if they didn't follow the Women in Neurosurgery Twitter account or use the hashtag #womeninneurosurgery. Moreover, this study did not look at other social media platforms such as Instagram, Facebook, LinkedIn and TikTok as it was building off a prior study that focused solely on Twitter.[15] Additionally, Twitter has become a common platform amongst the medical community recently for professional use. #MedTwitter is a common term penned to describe this leap of students, researchers, and physicians jumping to twitter for networking, medical education, and information sharing. Therefore, our results are applicable to the medical community on #MedTwitter, especially for those interested in neurosurgery, as it can inform them on who to follow.[29] Future directions can include doing an analysis of these other social media platforms as the medical community is flocking to not only Twitter, but various other platforms. More research needs to be done on elucidating the best social media strategies for various platforms including an analysis on type of posts, frequency posts, etc.

5. Conclusion

The significant positive association found between H-index and average likes, as well as H-index and follower count demonstrates that social media influence and academic productivity/influence may go hand in hand. Moreover, social media may be a way to increase gender equity in neurosurgery, as well as facilitate mentorship, knowledge sharing and community building between women neurosurgeons and others. By knowing who the top Twitter women neurosurgeon influencers are, others will be able to connect with them. This is especially relevant to women interested in neurosurgery or those in the field who are looking for mentorship, guidance, and role models. However, these findings can be applicable to anyone regardless of gender, or specialty of interest. Not only does understanding who the most influential women neurosurgeons on Twitter are increase the popularity of the influencers,

but it can also serve as guidance for individuals who are looking for mentorship. This can inspire individuals to pursue neurosurgery based off the content that the influencers post on their Twitter platforms. Additionally, neurosurgeons who are looking to start or enhance their social media presence on Twitters can model their strategies on those of the influencers identified. Further, patients can become more educated on neurosurgery by following these influencers and interacting with their educational posts.

CRediT authorship contribution statement

Vid Raturi: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Johnny Delashaw:** Writing – review & editing. **Aaron Dumont:** Writing – review & editing. **Arthur Wang:** Writing – review & editing, Writing – original draft, Supervision, Conceptualization.

Declaration of competing interest

The authors do not report any conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

References

1. Pew Research Center. *Social Media Fact Sheet*. Pew Research Center: Internet, Science & Tech; 2021, April 7. pewresearch.org/internet/fact-sheet/social- media/?tabId=tab-b14b718d–7ab6-46f4-b447-0abd510f4180.
2. Alotaibi NM, Badhiwala JH, Nassiri F, et al. The current use of social media in neurosurgery. *World Neurosurg.* 2016;88:619–624.e7. https://doi.org/10.1016/j.wneu.2015.11.011.
3. Zusman EE. Social media in academic neurosurgery. *World Neurosurg.* 2016;91:606–608. https://doi.org/10.1016/j.wneu.2016.02.118.
4. Shlobin NA, Hoffman SC, Clark JR, Hopkins BS, Kesavabhotla K, Dahdaleh NS. Social Media in neurosurgery: a systematic review. *World Neurosurg.* 2021;149:38–50. https://doi.org/10.1016/j.wneu.2021.01.135.
5. Linzey JR, Graffeo CS, Wang JZ, Haider AS, Alotaibi NM. Neurosurgery and the rise of academic social media: what neurosurgeons should know. *J Neurosurg.* 2018;129(4):1093–1097. https://doi.org/10.3171/2018.2.jns172817.
6. Association of American Medical Colleges. *2021 Fall Applicant, Matriculant, and Enrollment Data Tables*. Association of American Medical Colleges; 2021, December. https://www.aamc.org/media/57761/download?attachment.
7. Association of American Medical Colleges. *Active Physicians by Sex and Specialty*. vol. 2021. Association of American Medical Colleges; 2021, December 31. https://www.aamc.org/data-reports/workforce/data/active-physicians-sex-specialty-2021.
8. Association of American Medical Colleges. *Table B3. Number of Active Residents, by Type of Medical School, GME Specialty, and Sex*. Association of American Medical Colleges; 2021, August 18. aamc.org/data-reports/students- residents/data/report-residents/2021/table-b3-number-active-residents-type-medical- school-gme-specialty-and-sex.
9. Hdeib A, Elder T, Krivosheya D, et al. History of women in neurosurgery (wins). *Neurosurg Focus*. 2021;50(3). https://doi.org/10.3171/2020.12.focus20944.
10. Spetzler RF. Progress of women in neurosurgery. *Asian J. Neurosurg.* 2011;6(1):6–12. https://doi.org/10.4103/1793-5482.85627.
11. White Paper Committee WINS, Benzil DL, Abosch A, et al. The future of neurosurgery: a white paper on the recruitment and retention of women in neurosurgery. *J Neurosurg.* 2008;109(3):378–386. https://doi.org/10.3171/JNS/2008/109/9/0378.
12. Norton EJ, Bandyopadhyay S, Moudgil-Joshi J. Social media could address the gender gap in Neurosurgery. *Lancet Neurol*. 2020;19(5):382–383. https://doi.org/10.1016/s1474-4422(20)30080-6.
13. Garozzo D, Rispoli R, Graziano F, et al. Women in neurosurgery: historical path to self-segregation and proposal for an IntegratedFuture. *Front. Surgery*. 2022;9,908540. https://doi.org/10.3389/fsurg.2022.908540.
14. Bandyopadhyay S, Moudgil-Joshi J, Norton EJ, Haq M, Saunders KE. Motivations, barriers, and social media: a qualitative study of uptake of women into neurosurgery. *Br J Neurosurg.* 2020;36(1):19–25. https://doi.org/10.1080/02688697.2020.1849555.
15. Riccio I, Dumont AS, Wang A. The top 100 social media influencers in neurosurgery on Twitter. *Interdisciplinary Neurosurgery*. 2022;29(101545). https://doi.org/10.1016/j.inat.2022.101545.
16. Stevens CR, Merk K, Ierulli VK, Mulcahey MK. Analysis of social media posts that promote women surgeons. *J Surg Educ*. 2023;80(5):682–688. https://doi.org/10.1016/j.jsurg.2023.02.002.
17. Wang A, Dumont AS. Increased utilization of social media in neurosurgery during the COVID-19 pandemic. *World Neurosurgery*. 2020;143:575–576. https://doi.org/10.1016/j.wneu.2020.08.199.
18. Sungkur RK, Sebastien O, Singh UG. Social media as a catalyst for distant collaborative learning: trends and concerns for Small Island States. *Journal of the Knowledge Economy*. 2019;11(4):1454–1469. https://doi.org/10.1007/s13132-019-00613-4.
19. Hameed I, Oakley CT, Ahmed A, et al. Analysis of physician use of social media. *JAMA Netw Open*. 2021;4(7), e2118213. https://doi.org/10.1001/jamanetworkopen.2021.18213.
20. Office of the Director of National Intelligence. *Structural Drivers of the Future: Demographic Trends – the Future of Women's Rights*. 2021, June. dni.gov/index.php/gt2040-home/gt2040-deeper-looks/future-of- womensrights.
21. Steklacova A, Bradac O, de Lacy P, Benes V. E-WIN project 2016: evaluating the current gender situation in neurosurgery across Europe—an interactive, multiple-level survey. *World Neurosurgery*. 2017;104:48–60. https://doi.org/10.1016/j.wneu.2017.04.094.
22. Aslan A, Kuzucu P, Karaaslan B, Börcek AÖ. Women in neurosurgery: gender differences in authorship in high-impact neurosurgery journals through the last two decades. *World Neurosurgery*. 2020;138:374–380. https://doi.org/10.1016/j.wneu.2020.03.017.
23. Farhan SA, Shahid I, Siddiqi J, Khosa F. Assessing the gap in women authorship in Neurosurgery Literature: a 20-year analysis of sex trends in authorship. *World Neurosurgery*. 2020;141. https://doi.org/10.1016/j.wneu.2020.05.248.
24. Feng R, Hoffman SE, Wagner K, Ullman JS, Stippler M, Germano IM. Women neurosurgeons in academic and other leadership positions in the United States. *World Neurosurgery*. 2021;147:80–88. https://doi.org/10.1016/j.wneu.2020.12.069.
25. Ryan CA, Sciscent BY, Bhanja D, Tucker J, Daggubati LC. Women neurosurgery residency program directors in the United States: a cross-sectional descriptive analysis. *World Neurosurgery*. 2023;169:52–56. https://doi.org/10.1016/j.wneu.2022.10.091.
26. Midgley C, Lockwood P, Hu LY. Maximizing women's motivation in domains dominated by men: personally known versus famous role models. *Psychol Women Q*. 2023;47(2):213–230. https://doi.org/10.1177/03616843231156165.
27. Herrmann SD, Adelman RM, Bodford JE, Graudejus O, Okun MA, Kwan VS. The effects of a female role model on academic performance and persistence of women in STEM courses. *Basic Appl Soc Psychol*. 2016;38(5):258–268. https://doi.org/10.1080/01973533.2016.1209757.
28. Midgley C, DeBues-Stafford G, Lockwood P, Thai S. She needs to see it to be it: the importance of same-gender athletic role models. *Sex Roles*. 2021;85(3–4):142–160. https://doi.org/10.1007/s11199-020-01209-y.
29. Fieger E, Fadel K. #medtwitter: an open source medical community [version 2]. *MedEdPublish*. 2021;10(1). https://doi.org/10.15694/mep.2021.000019.2.