Social Media and the Dissemination of Research: Insights from the Most Widely Circulated Articles in Plastic Surgery

Joy Z. Zhou, B.A., M.H.S.
Benjamin T. Lemelman, M.D.
Nicolae Done, Ph.D.
Macey L. Henderson, J.D., Ph.D.
Alexandra Macmillan, M.A.(Cantab.), M.B.B.S.
David H. Song, M.D., M.B.A.
Amir H. Dorafshar, M.B.Ch.B.

Providence, R.I.; Chicago, Ill.; Boston, Mass.; Baltimore, Md.; and Washington, D.C.

Background: The purpose of this study is to quantify the relationship between social media use and the dissemination of research across nontraditional channels.
Methods: Between June and August of 2016, the authors identified 10 plastic surgery journals with the highest impact factor and their 10 most widely circulated articles. Article age; journal impact factor; "distinguished" article designation; and social media metadata of the first authors, last authors, and journals were incorporated into a multivariate regression model to predict the Altmetric Attention Score, a quantitative measure of popularity across Web-based media platforms.
Results: A total of 100 articles, 181 authors, and 10 journals were identified. Older articles tended to be less popular. The article's popularity was associated with the journal's audience size, but not with the author's social media activity. For each 1000 additional Twitter followers of the journal of publication, the Altmetric score is greater by a factor of 1.72 (95 percent CI, 1.076 to 2.749), which is the equivalent of 72 percent more Tweets. There is also a small but statistically significant negative association between the author's social media audience size and the popularity of his or her articles: for every 1000 additional followers, the Altmetric score is lower by a factor of 0.822 (95 percent CI, 0.725 to 0.932), which is the equivalent of 17.8 percent fewer Tweets.
Conclusion: The popularity of an article across social media platforms is associated with the journal's audience on social media, not with the magnitude of the author's social media activity. (*Plast. Reconstr. Surg.* 142: 555, 2018.)

There is evidence that academic medicine has begun embracing social media as a tool to establish an online presence, enhance visibility as a "thought leader," and engage with colleagues and patients.[1] Researchers and scientific journals use social media platforms such as Twitter, Facebook, YouTube, and LinkedIn to share scholarly works with the scientific community and the public. Traditionally, publishing one's work in a high-impact journal is a widely accepted indicator of scholarship. However, with built-in tools that allow users to "like," discuss, and share content with their existing social

From the Warren Alpert Medical School of Brown University; the Section of Plastic and Reconstructive Surgery, University of Chicago Medical Center; the Center for Access Policy, Evaluation and Research, Boston University School of Medicine; the Departments of Surgery and Plastic and Reconstructive Surgery, The Johns Hopkins University School of Medicine; and the Department of Plastic and Reconstructive Surgery, MedStar Georgetown University Hospital.
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A "Hot Topic Video" by Editor-in-Chief Rod J. Rohrich, M.D., accompanies this article. Go to PRSJournal.com and click on "Plastic Surgery Hot Topics" in the "Digital Media" tab to watch.

and professional networks, social media platforms are emerging as potential, alternative channels for disseminating knowledge. Two well-known institutions have taken a stand on the issue: Mayo Clinic and Johns Hopkins. At Mayo Clinic, social media activity is now evaluated when considering faculty for academic promotions[2]; however, Johns Hopkins has yet to explicitly include social media in its faculty promotion evaluation process.[3] Instead, the Johns Hopkins Faculty Gold Book cites at least two relevant components of scholarship that are taken into consideration before academic promotion: attainment of a "reputation beyond the School of Medicine" and "dissemination of knowledge to others." Social media use can facilitate both.

Recent articles have described the relationship between social media use and the dissemination of scientific knowledge in the fields of general surgery,[4] urology,[5] neurosurgery,[6] and dentistry.[7] The purpose of this study is to provide evidence that social media have penetrated the field of academic plastic surgery, to contextualize the discussion around formally recognizing social media use as part of the faculty-promotion process, and to delineate the limits of social media use data in helping us make these decisions. To examine the current levels at which authors and journals use social media, and to relate their social media use to how widely their articles are circulated on social media, we aim to describe the following: (1) social media use among authors of plastic surgery articles most widely circulated on Web-based platforms, blogs, and news outlets; (2) social media use among the highest impact plastic surgery journals; and (3) the relationship between social media use and the dissemination of research across social media platforms.

METHODS

Sampling Methodology

From June through August of 2016, we identified the top 10 plastic surgery journals by impact factor and their top 10 most widely circulated articles by Altmetric Attention Score (Altmetric score). The Altmetric score is an estimate of the magnitude of an academic article's dissemination across various Web-based media platforms. The algorithm takes into consideration frequency of clicks, references, and shares that a given article garners across Twitter, Facebook, news outlets, blogs, and others. Greater weight is assigned to exposure in higher quality sources, such as *The New York Times*; lower weight is assigned to exposure in less reputable or less well-known sources such as personal Facebook pages. By default, news outlets are assigned greater weight than blogs, which are assigned greater weight than Twitter and Facebook (Table 1).[8] Weights are further adjusted to reflect the magnitude of the reach that each source has. According to Altmetric developers, "a news mention from a popular national news outlet such as *The New York Times* will contribute more to the score than a news mention from a smaller, more niche publication such as *2 Minute Medicine*."[8] Thus, the Altmetric score allowed us to identify the top 10 articles from each of the top 10 plastic surgery journals most widely circulated across Web-based platforms, blogs, and news outlets.

Measures of Social Media Use

We defined "social media use" as having a social media presence, engaging in social media activity, and having a social media audience on several of the most popular social media sites: Twitter, Facebook, LinkedIn, Instagram, and YouTube. Between June and August of 2016, we collected publicly available metadata describing the social media presence, social media activity, and social media audience size of each journal, first author, and last author. To describe the journals' and authors' social media *presence* on these sites, we created a dichotomous indicator for whether an author had an identifiable account on each site. To evaluate the journals' and authors' social media *activity*, we collected the number of Tweets, likes, posts, and videos they had contributed on these sites. To analyze the journals' and authors' social media *audience size*, we collected the number of Twitter followers, Facebook page likes, LinkedIn followers, YouTube subscribers, YouTube channel views, and Instagram followers. The number of LinkedIn "connections" was excluded from analysis, as the maximum number of connections is a uniform value of "500+" connections.

Calculating Summary Statistics to Describe Social Media Use among Journals and Authors

To describe social media use among authors and journals of the most widely circulated articles, we calculated the proportions of authors and

Table 1. Default Weights of Sources That Contribute to the Altmetric Score, Unadjusted for Tier of Reach

Source	Weight
News	8.00
Blogs	5.00
Twitter	1.00
Facebook	0.25

journals who had a publicly identifiable account on Twitter, Facebook, LinkedIn, YouTube, and Instagram. We calculated the mean, median, and range of each measure describing social media activity and social media audience size.

Regression Modeling to Describe the Relationship between Authors' Social Media Use and Altmetric Scores

We fit regression models to describe the relationship between authors' social media use and Altmetric scores. Because of the skewed nature of the Altmetric score distribution (Fig. 1), we fit a generalized linear model that described the relationship between the first author's social media audience size (measured in thousands of Twitter followers) and the popularity of his or her article. We conducted a modified Park test to determine the most appropriate distribution family,[9] which indicated either a Poisson or gamma distribution. To avoid overdispersion issues frequently encountered in Poisson models, our generalized linear model specification assumes a gamma distribution for this outcome and uses a log link to model the expected value.[10] Here, we present the results of our analyses with the first authors only, because not every article has a last author. In a separate analysis, we created measures summing up the social media use of the first and last authors. The effects of the last authors' social media use did not change our conclusion, and we therefore restrict our analysis to social media activity of the first authors.

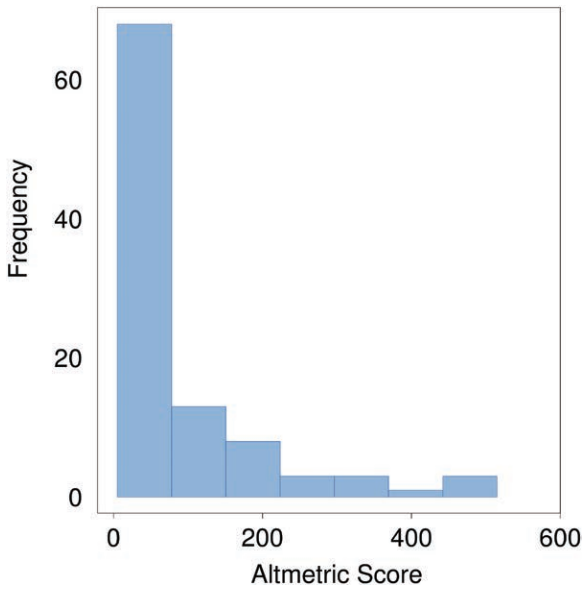

Fig. 1. Distribution of Altmetric scores of the 100 most widely circulated plastic surgery articles on Web-based media sites.

We built on our model by including journal social media activity and journal social media audience size, to describe the relationship between social media use and Altmetric scores. In simpler models, we describe the relationship between the first authors' social media use and Altmetric scores of their articles. We then built on these models by adding in journals' social media use and social media audience size as covariates. Lastly, we fit ordinary least-squares linear regression models using the same covariates.

Selecting a Subset of Measures of Social Media Use for Regression Models

We determined that measures of activity and audience size across Facebook, Instagram, LinkedIn, and YouTube are highly correlated. Therefore, in a preliminary data reduction stage, we considered for elimination any variables with a Pearson correlation coefficient higher than 0.7 for which we also had reasons to believe were jointly determined. For example, Facebook audience size was highly correlated with Twitter audience size, so we favor a parsimonious model that includes only Twitter audience size.

We also considered for elimination any measures related to social media sites that few authors used. For example, only 18 of 181 authors had a YouTube channel, and only 10 of 181 authors had an Instagram account. We therefore eliminated measures of activity and audience size on these two platforms from our model's specifications. All models include characteristics of the articles that are likely to influence the Altmetric score: the journal impact factor, the age of the article at the time of data collection, and whether the article was classified by the journal as a distinguished article. Although the Altmetric score is not adjusted for age of the article, our observations suggest that Altmetric scores tend to peak and then plateau at 3 months after publication, which suggests that articles older than 3 months are relatively stable in popularity and can be compared with articles across different ages.

Outliers/Alternative Samples

We identified two articles whose authors' unusually high levels of social media use suggested that the articles may be outliers in this sample. We fit alternative models using a subset that excluded these outlier articles.

Preferred Model

Our preferred model is a generalized linear model with specifications that include

characteristics of the article and the journal of publication that may affect Altmetric scores, such as the journal impact factor, the age of the article at the time of data collection, and whether the article was classified by the journal as a distinguished article. Our preferred model uses Tweets as a measure of social media activity and the number of Twitter followers as a measure of audience size. Our preferred model (Model 4) describes the relationship between Altmetric score and social media use by the article's first author, and excludes outliers. For this generalized linear model model, each coefficient can be interpreted as the multiplicative change in Altmetric score per one-unit increase in any given covariate, holding the other measures constant. For ordinary least-squares regression models, in contrast, each coefficient can be interpreted as the additive change in Altmetric score per one-unit increase in any given covariate, holding the other measures constant. We performed all statistical analyses using Stata version 14.2 (StataCorp LLC, College Station, Texas).

RESULTS

Social Media Use among Journals and Authors

The estimates of social media use, as defined by these measures of social media presence, activity, and audience size, are displayed in Tables 2 and 3. Among the 181 first and last authors of the 100 most widely circulated articles published in the top plastic surgery journals., the most popular social media platforms are LinkedIn, with 58 percent of authors having an identifiable page (n = 105), followed by Facebook (n = 54), Twitter (n = 43), YouTube (n = 18) and personal blogs (n = 18), and Instagram (n = 10). (**See Table, Supplemental Digital Content 1**, which shows journal names, impact factor, article titles, and Altmetric scores for all articles in the study sample, ***http://links.lww.com/PRS/C886***.) We also show social media use separately for first and last authors of the most widely circulated plastic surgery articles. (**See Table, Supplemental Digital Content 2**, on Web-based media sites by Altmetric score, ***http://links.lww.com/PRS/C887***.)

Table 2. Key Indicators of Social Media Use for 181 Authors of the Most Widely Circulated Plastic Surgery Articles on Web-Based Media Sites by Altmetric Score

Indicator*	Median	Mean	Range
Twitter (n = 43)			
Tweets	116	3956	1–80,800
Likes	11	3588	0–125,000
Followers	99	7395	0–102,000
Following	100	1967	0–64,000
Facebook (n = 54)			
Page likes	0	1341	0–48,084
LinkedIn (n = 105)			
Posts	3	1	0–5
Followers	179	430	0–7163
YouTube (n = 18)			
Videos	15	39	1–256
Subscribers	16	393	0–3615
Channel views	0	91,388	0–1,518,439
Instagram (n = 10)			
Posts	46	143	0–707
Followers	135	593	1–2291
Following	48	1060	1–7275

*n indicates the number of authors who had a public, identifiable account on this platform. Authors without an identifiable account are excluded from the calculation of mean, median, and range. Means are rounded up to the nearest integer.

Table 3. Key Indicators of Social Media Use for the Top 10 Plastic Surgery Journals by Impact Factor

Indicator*	Median	Mean	Range
Twitter (n = 7)			
Tweets	1244	3361	317–14,300
Likes	3	599	0–3499
Followers	537	2550	76–9577
Following	123	1014	0–5090
Facebook (n = 5)			
Likes	315	3300	60–12,821
LinkedIn (n = 1)			
Posts	0	0	
Followers	865	865	
YouTube (n = 3)			
Videos	204	167	64–233
Subscribers	787	1546	245–3604
Instagram (n = 1)			
Posts	20	20	
Followers	28	28	
Following	2	2	

*n indicates the number of journals that had a public, discoverable account on this platform. Journals without an identifiable account are excluded from the calculation of mean, median, and range. Means are rounded up to the nearest integer.

Among the top 10 plastic surgery journals, the most popular social media platform is Twitter (n = 7 journals), followed by Facebook (n = 5), YouTube (n = 3), LinkedIn (n = 1), and Instagram (n = 1). No single journal has profiles on all five social media sites, and three journals had no profiles on any of the social media sites. Only one journal had a profile on LinkedIn, and therefore LinkedIn use by journals was not used in further analysis.

Relationship between Authors' Social Media Use and Altmetric Scores

We find that social media audience size is highly associated with social media activity. The correlation coefficients between indicators of social media presence, activity, and audience size across multiple platforms for authors and journals are shown. (**See Table, Supplemental Digital Content 3**, which shows correlation coefficients

for measures of authors' social media use, ***http://links.lww.com/PRS/C888***. **See Table, Supplemental Digital Content 4**, which shows correlation coefficients for measures of journals' social media use, ***http://links.lww.com/PRS/C889***.)

Table 4 shows the results of all considered models that describe the relationship between social media use and Altmetric scores. We consider coefficients statistically significant at a precision cutoff level of 0.05. Using our preferred model (Model 4), we find no statistically significant relationship between authors' social media activity and the Altmetric scores of their articles. Instead, we find that Altmetric scores are associated with the journal's Twitter followers. For each 1000 additional Twitter followers, the Altmetric score is greater by a factor of 1.72 (95 percent CI, 1.076 to 2.749), which is the equivalent of 75 percent more Tweets, 14.4 percent more shares on a blog, or 9 percent more mentions in the news.

There appears to be a negative association between authors' Twitter followers and the Altmetric scores of their articles. For every 1000 additional Twitter followers, the Altmetric score is lower by a factor of 0.82 (95 percent CI, 0.725 to 0.932), which is the equivalent of 17.8 percent fewer Tweets, 3.56 percent fewer shares on a blog, or 2.3 percent fewer mentions in the news.

Older articles tend to have lower Altmetric scores. We found no statistically significant relationship between the journal impact factor and Altmetric score, nor between designation as a "distinguished" article and Altmetric score after controlling for the social media use of the author and the journal in which the article was published.

For comparison's sake, we also show the results of all considered generalized linear model models that describe the relationship between social media use and Altmetric scores. We also include the results of all ordinary least-squares linear models. (**See Table, Supplemental Digital Content 5**, which shows risk ratio estimates describing the associations between indicators of social media use and Altmetric scores from ordinary least-squares linear regression models, ***http://links.lww.com/PRS/C890***.)

DISCUSSION

This is the first study to describe the association between social media use and popularity of academic plastic surgery articles across various Web-based media platforms. We found evidence that social media audience size of the journal is associated with the popularity of academic articles across multiple Web-based media platforms.

Table 4. Risk Ratio Estimates Describing the Association between Indicators of Social Media Use and Altmetric Scores from Generalized Linear Regression Models

	All Articles		Without Outliers	
Variables	**Model 1 (Unadjusted)**	**Model 2 (Adjusted)**	**Model 3 (Unadjusted)**	**Model 4 (Adjusted)**
Journal impact factor				
RR	1.814	0.201	1.862	0.218
95% CI	0.712–4.618	0.021–1.892	0.712–4.867	0.021–2.254
Distinguished				
RR	2.350	1.386	2.532	1.454
95% CI	0.591–9.343	0.666–2.884	0.622–10.302	0.612–3.452
Article age (mo)				
RR	0.996*	0.997*	0.996*	0.997*
95% CI	0.994–0.998	0.995–0.998	0.994–0.998	0.995–0.998
Twitter followers, first author (thousands)				
RR	1.000	0.990‡	0.857	0.822*
95% CI	0.956–1.046	0.977–1.002	0.691–1.062	0.725–0.932
Twitter followers, journal (thousands)				
RR		1.750†		1.720†
95% CI		1.118–2.740		1.076–2.749
Twitter tweets, journal (thousands)				
RR		0.905*		0.914†
95% CI		0.839–0.976		0.839–0.997
Constant				
RR	25.011*	743.733*	23.874*	654.543*
95% CI	4.951–126.348	26.131–21,168.198	4.567–124.786	19.543–21,922.028
Observations	100	100	98	98

RR, risk ratio.
*$p < 0.01$.
†$p < 0.05$.
‡$p < 0.1$.

There appears to be a small but statistically significant negative association between the author's level of social media activity and the popularity of his or her article. One possible explanation is that authors do not specifically use social media as a channel to promote their own work. Instead, they may engage in high levels of social media use to derive other benefits, such as connections with peers or promotion of products or services. Our study demonstrates the opportunity for individual authors with existing social media accounts to begin sharing their works.

Our study is inherently limited by our sampling methodology, which selected a small subset of the full population of academic plastic surgery articles and their authors. Our sample includes articles that have had substantial social media popularity published in higher impact journals, but excludes articles that are not popular on social media or are published in lower impact journals. This may partially explain the lack of a significant association between journal impact factor and Altmetric scores. Because our sample is composed of articles from the top 10 journals by impact factor, there may not be enough variation in impact factors to explain the variation in Altmetric scores.

Another limitation of the study involves the main outcome measure—the Altmetric score. Although the basic method and default weights involved in calculating the Altmetric score are publicly shared, the algorithm incorporates additional adjustments for indications that authors are self-promoting the article by means of social media. The underlying justification is that the Altmetric score is intended to measure "organic" popularity driven by natural interest in the article. Moreover, as the Altmetric score is an evolving research tool, the algorithm is subject to change over time.

Twitter is widely known for its large number of "bots," which make up an estimated 48 million accounts as of March of 2017 and may be responsible for a significant proportion of activity on Twitter.[11] The Altmetric score does not differentiate between Tweets generated by humans or bots, and consequently we were not able to assess the proportion of social media activity driven by bots. Future research should develop methods to identify and adjust for Twitter activity by nonhuman accounts, which influence Tweet and follower counts.[7] In addition, even when Tweets are generated by humans, it is difficult to assess the extent to which Tweets represent genuine enthusiasm and engagement with that scientific work.[12]

There are unmeasured factors that influence an article's popularity, including whether an article benefited from a journal's press release, and the article's open access status. For example, although the literature suggests open access articles do not have a citation advantage in academia,[13–15] it is possible that dissemination of research across nonacademic channels may be sensitive to an article's accessibility.

Although this study allows us to describe the levels of social media activity for authors and journals in this field in a relatively systematic way, the cross-sectional nature of the study, in addition to the sampling methodology, prevents us from being able to make causal inferences. Currently, our best tool for quantifying "scholarship" is the h-index, an author-level measure of academic impact based on how many articles an author has published and how many times each of those articles has been cited. The h-index estimates scientific output and is widely used in academic institutions when making tenure and promotion recommendations. Because academic citations may take months to change substantially, the utility of the h-index is limited by its favorable bias toward older authors, who have accumulated many years' worth of citations of their works. In a modern age of communication technology, social media metrics may provide a more granular level of insight by making it possible to analyze the dissemination of research in real time.

Whether social media use should be taken into consideration as a part of academic promotions depends on whether an institution decides to broaden the definition of "scholarship" to include dissemination of research across nontraditional channels such as social media platforms. Hypothetically, an institution could use the Altmetric scores of a faculty member's publications to supplement estimates of scholarly impact by factoring the Altmetric scores into the evaluation of the extent to which a faculty member has achieved "dissemination of knowledge" and cultivated a "reputation beyond medicine."[3] This would establish an incentive structure in which academic promotion is, in part, determined by popularity on social media sites. This incentive structure may have unintended consequences (e.g., by rewarding "heavy users" of social media indiscriminately for "scholarly" and "nonscholarly" social media use). Without a mechanism to detect self-promotion among seemingly "scholarly" social media activity, we may inadvertently encourage authors to share their own work frequently and widely on various social media platforms. Anyone can

create a Twitter account and share links to his or her work, but that does not necessarily result in meaningful "dissemination of knowledge." If an institution can establish these parameters, and we develop better analytical tools to evaluate social media content, perhaps data on social media use can supplement existing and well-established measures of academic output, such as the h-index.

The study of social media reach of academic work is relatively novel, and its implications are not well understood. Future studies can focus on larger samples of academic articles across different fields, and use longitudinal study designs to better assess the causal effect of social media use on the dissemination of new knowledge beyond traditional academic channels.

Amir H. Dorafshar, M.B.Ch.B.
Johns Hopkins Outpatient Center
601 North Caroline Street, Suite 8161
Baltimore, Md. 21287
adorafs1@jhmi.edu

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