Does Tweeting Improve Citations? One-Year Results from the TSSMN Prospective Randomized Trial

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Background. **The Thoracic Surgery Social Media Network (TSSMN) is a collaborative effort of leading journals in cardiothoracic surgery to highlight publications via social media. This study aims to evaluate the 1-year results of a prospective randomized social media trial to determine the effect of tweeting on subsequent citations and nontraditional bibliometrics.**

Methods. **A total of 112 representative original articles were randomized 1:1 to be tweeted via TSSMN or a control (non-tweeted) group. Measured endpoints included citations at 1 year compared with baseline, as well as article-level metrics (Altmetric score) and Twitter analytics. Independent predictors of citations were identified through univariable and multivariable regression analyses.**

Results. **When compared with control articles, tweeted articles achieved significantly greater increase in Altmetric scores (Tweeted 9.4 ± 5.8 vs Non-tweeted 1.0 ± 1.8, $P < .001$), Altmetric score percentiles relative to articles of similar age from each respective journal (Tweeted 76.0 ± 9.1 percentile vs Non-tweeted 13.8 ± 22.7 percentile, $P < .001$), with greater change in citations at 1 year (Tweeted +3.1 ± 2.4 vs Non-Tweeted +0.7 ± 1.3, $P < .001$). Multivariable analysis showed that independent predictors of citations were randomization to tweeting (odds ratio [OR] 9.50; 95% confidence interval [CI] 3.30-27.35, $P < .001$), Altmetric score (OR 1.32; 95% CI 1.15-1.50, $P < .001$), open-access status (OR 1.56; 95% CI 1.21-1.78, $P < .001$), and exposure to a larger number of Twitter followers as quantified by impressions (OR 1.30, 95% CI 1.10-1.49, $P < .001$).**

Conclusions. **One-year follow-up of this TSSMN prospective randomized trial importantly demonstrates that tweeting results in significantly more article citations over time, highlighting the durable scholarly impact of social media activity.**

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The Thoracic Surgery Social Media Network (TSSMN) was formed in 2015 as a collaborative effort between *The Annals of Thoracic Surgery* and *The Journal of Thoracic and Cardiovascular Surgery*.[1] The primary goals of the initiative were to bring social media attention to key publications from both journals and to highlight major accomplishments in cardiothoracic surgery. TSSMN has established a presence in the social media community, achieving its goals through the activity of delegates who tweet content related to recent journal publications, live-tweet the specialty's annual meetings, and host 1-hour live TweetChats featuring key articles published in cardiothoracic surgery to engage manuscript authors, readers, and the virtual community in scholarly discussion.[2-6]

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Article level metrics (Altmetrics) are emerging as an important measure of academic impact[7] and are intended to be a complementary online dimension to traditional citation-based metrics with real-time data addressing how articles are shared and discussed globally. Importantly, previous investigations have demonstrated that high levels of online social media attention are correlated with subsequent increases in article access and citations.[8]

We have previously reported on short-term results of a prospective randomized trial demonstrating that scheduled tweeting of original research published in *The Annals of Thoracic Surgery* and *The Journal of Thoracic and Cardiovascular Surgery* via TSSMN improves early non-traditional bibliometrics of dissemination.[9] The present study aims to evaluate the longer-term impact (1 year) after completion of the prospective randomized social media trial, of tweeting on citations and whether non-traditional bibliometrics correlate with citations over time.

Patients and Methods

Inclusion Criteria

One hundred twelve representative original scientific articles published from 2017-2018 in *The Annals of Thoracic Surgery* and *The Journal of Thoracic and Cardiovascular Surgery* were randomly selected for inclusion in the study. Of the 112 articles, 56 (50%) articles, equally distributed among research categories (education, general thoracic surgery, adult cardiac surgery, congenital cardiac surgery), were then randomly allocated to the group to be tweeted and 56 (50%) were allocated to the control group (non-tweeted).

Exclusion Criteria

Articles that were not reporting on original scientific research were excluded— i.e., reviews, editorials, letters to the Editor, and case reports. Furthermore, articles that had been previously tweeted via TSSMN were also excluded from the study.

Study Protocol

We have previously published in detail our study protocol for the present trial.[9] In brief, 4 articles were prospectively tweeted per day by a designated TSSMN delegate (JL) and retweeted by all other TSSMN delegates (n = 11) with a combined followership of 52,893 individuals and @TSSMN for 14 days from June 4, 2018, to June 17, 2018. TSSMN delegates were instructed to only retweet and not interact with the tweet in any other way (ie, by liking, commenting, or clicking on the media content, URL [uniform resource locator], or hashtag) for the purposes of standardization. The headline and social media summary were standardized to be written in simple English to convey the main point of each article, the authors and institutions involved in the study, and a link to the full-text version of the article on the respective journal's website. Each article served as its own baseline control. In addition, to further reduce the possibility of unmeasured confounders by using a randomized design, each article was also compared to a control article that was published in the same issue, of the same article type and research category. For the control group, no tweets or social media activity were planned.

Study Design

A power calculation was not performed because the relevant effect size for this study remains unknown. A size of 56 articles to be tweeted was chosen so that 4 articles could be tweeted per day at various times over a course of focused tweeting of 14 days. This study was intended to simulate and evaluate the effect of a feasible focused tweeting period with engagement of all TSSMN delegates. The study did not meet criteria for human subjects research and was exempt from review by our institutional review board.

Outcomes

Measured outcomes included citations at 1 year compared with baseline, as well as article-level metrics (Altmetric score) and Twitter analytics.

Article-level metrics have been proposed as an alternative way of quantifying journal impact, which is traditionally expressed as the journal impact factor. Altmetrics track the impact of publications at the article level by the digital object identifier for impact beyond citations, including Mendeley reads.[9] The colors of the Altmetric doughnut each represent a different source of attention and the relative amount of each color depends on which sources of attention have been garnered by a given research output. Attention from all sources is tracked in real-time or daily feeds, and, as such, the color complements of the doughnut and score may change daily.[9] The Altmetric score is derived from an automated algorithm and weighted by the relative importance of the medium and the mentioner.

Twitter analytics include impressions, engagements, retweets, likes, URL clicks, hashtag clicks, detail expansion, media views and media engagements. As defined by Twitter, impressions are the number of times article tweets were viewed by unique individuals, whereas engagements are the events in which individuals interacted with a tweet (retweets, likes, link clicks, etc).[10]

Statistical Analyses

An intention-to-tweet analysis of all randomized articles was undertaken to compare the effect of tweeting via TSSMN vs the control group of no dedicated tweeting. Prespecified subgroups were also analyzed. Parametric continuous variables expressed as mean ± standard deviation was compared by use of the Student's *t* test. Nonparametric continuous variables expressed as medians (interquartile range) were compared by use of the Mann-Whitney U test. Categorical data were expressed as counts and percentages and χ^2 test was used to analyze differences between groups. Independent predictors of citations were identified through univariable and

multivariable regression analyses. Statistical analyses were performed using Stata (Stata Corp, College Station, TX) with significance set at a P value of .05.

Results

Baseline Demographics

The combined followership of all TSSMN delegates was 52,983. In the comparison of baseline characteristics between the 56 articles that were allocated to be tweeted and the 56 articles that were used as controls, there were no differences in baseline citations, Altmetric scores, prior tweets, or social media posts, Mendeley reads, or open access status (Table 1).

Twitter Analytics of TSSMN Tweets

Follow-up of tweeting via TSSMN at 1 year generated an average of 3569 impressions and 74 engagements per tweet for each article (Table 2). Per tweet, there was an average of 13 retweets, 10 likes, 14 link clicks to the respective journal website to view the full text, 12 detail expansions, 11 media views, and 14 media engagements.

Effect of Tweets on Altmetric Scores and Citations

Articles randomized to tweeting experienced a substantially greater change at 1-year follow-up in Altmetric score (Tweeted +9.4 ± 5.8 vs Non-Tweeted 1.0 ± 1.8, p<0.001), Mendeley reads (Tweeted +9.2 ± 7.5 vs Non-Tweeted 3.2 ± 6.1, p<0.001) and citations (Tweeted +3.1 ± 2.4 vs Non-Tweeted +0.7 ± 1.3, p<0.001) (Figure 1A) (Table 2). When compared to articles that were not tweeted, tweeted articles achieved significantly higher Altmetric score percentile relative to articles of similar age from each respective journal (Tweeted 76.0 ± 9.1 percentile vs Non-Tweeted 13.8 ± 22.7 percentile, $P < .001$) (Figure 1B and 1C). Altmetric score percentile strongly correlated with citations (r = 0.72, $P < .001$). There were no significant differences in 1-year follow-up change in Altmetric score, Mendeley reads, and citations among different categories of articles (education, general thoracic surgery, adult cardiac surgery, and congenital cardiac surgery (data not shown).

Table 1. Baseline Article Characteristics (Tweeted vs Non-Tweeted)

	Tweeted	Non-Tweeted	P Value
Citations	1.0 ± 0.4	1.3 ± 0.5	.865
Altmetric score	0.7 ± 1.8	0.9 ± 2.3	.432
Tweets	1.0 ± 3.1	1.5 ± 3.5	.457
Facebook posts	0.0 ± 0.1	0.0 ± 0.1	>.999
Mentioned in Google Plus	0.0 ± 0.0	0.0 ± 0.0	>.999
Reddited	0.0 ± 0.1	0.0 ± 0.0	.319
Picked up by news outlet	0.0 ± 0.1	0.0 ± 0.0	.319
Blogged	0.0 ± 0.0	0.0 ± 0.0	>.999
Mendeley reads	1.2 ± 2.8	0.9 ± 2.4	.515
Connotea	0.0 ± 0.0	0.0 ± 0.0	>.999
CiteULike	0.0 ± 0.0	0.0 ± 0.0	>.999
Exposure to Twitter followers	2715.4 ± 11,393.3	2564.3 ± 6780.4	.932
Open access, %	59	66	.440

Values are expressed as mean ± standard deviation unless otherwise marked.

Table 2. Social Media Impact of Articles Comparing Before and After Tweeting Via TSSMN at 1 Year of Follow-Up

	Tweeted	Non-Tweeted	P Value
Change in citations	3.1 ± 2.4	0.7 ± 1.3	<.001
Change in Altmetric			
Score	9.4 ± 5.8	1.0 ± 1.8	<.001
Tweets	15.0 ± 3.8	0.0 ± 0.1	<.001
Mendeley Reads	9.2 ± 7.5	3.2 ± 6.1	<.001
Change in Twitter analytics			
Impressions	1969.5 ± 138.6	…	NA
Total engagements	15.6 ± 20.7	…	NA
Retweets	1.2 ± 1.3	…	NA
Likes	1.3 ± 1.5	…	NA
URL clicks	2.6 ± 4.1	…	NA
Hashtag clicks	0.1 ± 0.4	…	NA
Detail expand	3.4 ± 5.5	…	NA
Media views	5.8 ± 12.1	…	NA
Media engagements	3.9 ± 11.2	…	NA

NA, not available; TSSMN, Thoracic Surgery Social Media Network.

Predictors of Citations

On multivariable analysis, independent predictors of citations included being randomized to tweeting (odds ratio [OR] 9.50; 95% confidence interval [CI] 3.30-27.35, $P < .001$), Altmetric score (OR 1.32; 95% CI 1.15-1.50, $P < .001$), open access status (OR 1.56; 95% CI 1.21-1.78, $P < .001$), and exposure to a larger number of Twitter followers as quantified by impressions (OR 1.30, 95% CI 1.10-1.49, $P < .001$). Specifically, citations were predicted by Twitter exposure to scientists (OR 1.57; 95% CI 1.25-1.96, $P < .001$), physicians (OR 1.86; 95% CI 1.33-2.60, $P < .001$), and the media (OR 2.75; 95% CI 1.38-5.46, $P = 0.004$).

Comment

Academic scholarship has been conventionally judged by metrics related to citations; these metrics have likewise been used in the assessment of the quality of an individual's scholarly contributions.[11] Altmetrics, or article-level metrics, are emerging as alternative measures of academic impact by quantifying social media attention of scholarly work and public engagement.[11] In principle, it is plausible that increased social media exposure for articles may translate into increased article dissemination and usage, thus warranting journal-driven social media efforts. Nevertheless, concrete data to support efforts for social media engagement are lacking.

The present study reports on the results of a 1-year follow-up of the prospective randomized trial aimed to

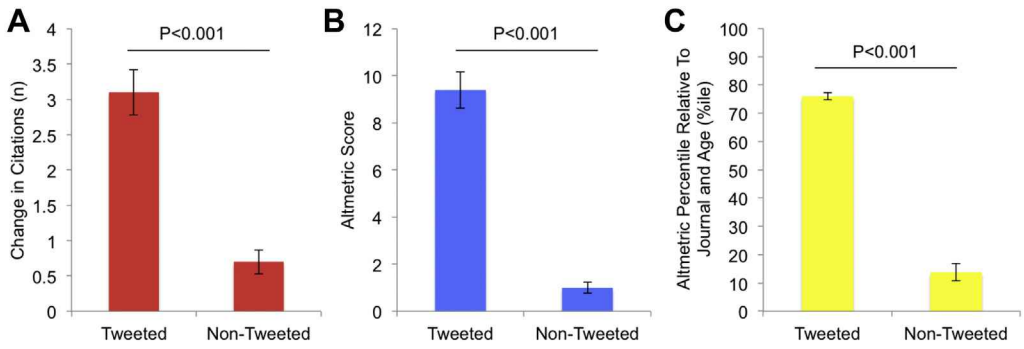

Figure 1. One-year outcomes of the Thoracic Surgery Social Media Network Randomized Prospective Social Media Trial demonstrating tweeting improves change in (A) citations; (B) Altmetric score; and (C) Altmetric percentile relative to journal and age.

study the role of the social media group TSSMN in the dissemination of cardiothoracic surgery scholarly literature. We demonstrate that, compared with articles not tweeted that were used as controls, articles randomized to tweeting experienced substantially higher Altmetric scores, greater Altmetric score percentiles relative to articles of similar age from the respective journal, and greater increases in citations at 1 year. On multivariable analysis, independent predictors of citations included being randomized to tweeting, Altmetric score, open access status, and exposure to a larger number of Twitter followers.

Previous work exploring the potential of tweeting to increase journal article dissemination has resulted in findings that have been mixed. A randomized trial conducted by Fox and associates[12,13] of articles published in *Circulation* did not demonstrate a difference in 30-day page views for articles that were tweeted and posted to Facebook when compared with those that were not. In contrast, a randomized trial showed that tweeting articles from *Academic Medicine*[14] and *Cochrane Reviews*[15] increased page views at 30 days and 7 days of follow-up, respectively. Furthermore, Hawkins and colleagues[16,17] demonstrated that physician-led programs to tweet about articles accrue higher online engagement as quantified by weekly page views than tweets originating only through Twitter accounts managed by the journals themselves. Recognizing that page views are only one aspect of social media exposure, other studies have demonstrated that article mentions on Twitter (within days of publication) correlated highly with eventual citations;[8] however, other studies of Altmetrics (including Twitter mentions) of articles demonstrate weak relationships with article access and eventual citation.[18-20]

Our study contributes to the ongoing research on the efficacy of social media strategies to improve article reach by using a rigorous study design, randomizing articles 1:1 to be tweeted or not, and performing longitudinal follow-up of multiple metrics of scholarly dissemination at 1-year's time including Altmetric scores and citations. We add to our prior study[9] that demonstrates that there is a rise in social media impact (Altmetric scores and Twitter analytics) in relation to article tweets with a plateau effect on early follow-up of 7 days by furthering this finding with demonstrated translation to change in citations at 1 year of follow-up. Our finding of an association between open access status and citations has implications for authors and journals to consider their open access policies to increase readership. Regardless of the modality for dissemination, our study suggests that greater public accessibility for a public and scientific readership may contribute to higher Altmetric score, Altmetric percentile, and, ultimately, citations.

We demonstrate the feasibility of establishing a social media working group (TSSMN) with large social media followership of 52,983 consisting of key opinion leaders in cardiothoracic surgery and the impact of their tweeting activity on alternative article-level metrics and citations. Future use of more comprehensive social media strategies and their effects on article dissemination should be tested in a similarly rigorous manner.

Study Limitations

Our study is subject to a number of limitations that must be considered in the interpretation of the data. Although we were able to demonstrate social media impact and attention, alternative metrics do not differentiate between positive and negative attention as well as quality of the tweet or article. It is possible that citations occur because of the importance of the article, irrespective of targeted social media dissemination of the article via TSSMN. No single metric provides a reader with a comprehensive measurement of the quality and importance of an article and are each subject to their own set of limitations.[21] Our study is limited in sample size, confined to articles published in *The Annals of Thoracic Surgery* and *The Journal of Thoracic and Cardiovascular Surgery*, where the large followership of TSSMN can limit the replicability of this approach for implementation in other journals. It is possible that social media campaigns over a limited timespan with high frequency can lead to tweet burnout for followers; in this study, however, there was no significant change in viewer engagement over the 2-week period. Furthermore, we were unable to account for social media activity of other Twitter users who may have promoted the article, in addition to TSSMN, which may confound our results. Future studies will aim to correlate social media attention to long-term article citations and

journal impact factor. Furthermore, TSSMN looks forward to expanding its efforts in disseminating cardiothoracic surgical scholarship to other social media platforms.

Conclusions

One-year follow-up of this TSSMN prospective randomized trial importantly demonstrates that tweeting results in significantly greater article citations, highlighting the prolonged scholarly impact of social media activity. Moreover, social media attention, as measured by nontraditional bibliometrics of dissemination, was predictive of article citations. Longer-term studies with correlation of article-level metrics with traditional endpoints of journal citations and impact factor are needed.

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References

1. Antonoff MB. Thoracic Surgery Social Media Network: bringing thoracic surgery scholarship to Twitter. *Ann Thorac Surg*. 2015;100:383-384.
2. Luc JGY, Varghese TK Jr, Antonoff MB. Participating in TweetChat: practical tips from the Thoracic Surgery Social Media Network (#TSSMN). *Ann Thorac Surg*. 2019;107:e229-e233.
3. Luc JGY, Antonoff MB. Live tweet the Society of Thoracic Surgeons Annual Meeting: how to leverage Twitter to maximize your conference experience. *Ann Thorac Surg*. 2018;106:1597-1601.
4. Luc JGY, Stamp NL, Antonoff MB. Social media in the mentorship and networking of physicians: important role for women in surgical specialties. *Am J Surg*. 2018;215:752-760.
5. Luc JGY, Ouzounian M, Bender EM, et al. The Thoracic Surgery Social Media Network: early experience and lessons learned. *Ann Thorac Surg*. 2019;108:1248-1255.
6. Ni Hlci T, Archer M, Harrington C, Luc JGY, Antonoff MB. The Trainee Thoracic Surgery Social Media Network: a pilot study in social media use. *Ann Thorac Surg*. 2019;109:285-290.
7. Elmore SA. The Altmetric attention score: what does it mean and why should I care? *Toxicol Pathol*. 2018;46:252-255.
8. Eysenbach G. Can tweets predict citations? Metrics of social impact based on Twitter and correlation with traditional metrics of scientific impact. *J Med Internet Res*. 2011;13:e123.
9. Luc JGY, Archer MA, Arora RC, et al. Social media improves cardiothoracic surgery literature dissemination: results of a randomized trial. *Ann Thorac Surg*. 2020;109:589-595.
10. Twitter. Glossary. Available at: https://help.twitter.com/en/glossary. Accessed April 30, 2019.
11. Kwok R. Research impact: Altmetrics make their mark. *Nature*. 2013;500:491-493.
12. Fox C, Gurary E, Ryan J, et al. Randomized control trial of social media: effect of increased intensity of the intervention. *J Am Hear Assoc*. 2016;5:e003088.
13. Fox C, Bonaca M, Ryan J, Massaro J, Barry K, Loscalzo J. A randomized trial of social media from Circulation. *Circulation*. 2015;131:28-33.
14. Maggio L, Leroux T, Artino AJ. To tweet or not to tweet, that is the question: a randomized trial of Twitter effects in medical education. *PLoS One*. 2019;14:e0223992.
15. Adams C, Jayarm M, Bodart A, Sampson S, Zhao S, Montgomery A. Tweeting links to Cochrane Schizophrenia Group reviews: a randomized controlled trial. *BMJ Open*. 2016;6:e010509.
16. Hawkins CM, Hillman BJ, Carlos RC, Rawson JV, Haines R, Duszak R. The impact of social media on readership of a peer-reviewed medical journal. *J Am Coll Radiol*. 2014;11:1038-1043.
17. Hawkins CM, Hunter M, Kolenic GE, Carlos RC. Social media and peer-reviewed medical journal readership: a randomized prospective controlled trial. *J Am Coll Radiol*. 2017;14:596-602.
18. Tonia T, Van Oyen H, Berger A, Schindler C, Kunzli N. If I tweet will you cite? The effect of social media exposure of articles on downloads and citations. *Int J Public Health*. 2016;61:513-520.
19. Thelwall M, Haustein S, Larivière V, Sugimoto CR. Do Altmetrics work? Twitter and ten other social web services. *PLoS One*. 2013;8:e64841.
20. Amath A, Ambacher K, Leddy JJ, Wood TJ, Ramnanan CJ. Comparing alternative and traditional dissemination metrics in medical education. *Med Educ*. 2017;51:935-941.
21. Trueger N, Thoma B, Hsu C, Sullivan D, Peters L, Lin M. The Altmetric score: a new measure for article-level dissemination and impact. *Ann Emerg Med*. 2015;66:549-553.