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Authors

Chandra, Neha
Hsiao, Ruth
Shapiro, Hilary
et al.

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ORIGINAL RESEARCH

Women in Cardiology Twitter Network: An Analysis of a Global Professional Virtual Community From 2016 to 2019

Neha V. Chandra , MD; Ruth Hsiao , MD; Hilary Shapiro , MD, MSc; Sarah Snow , MD; Katie Truong , MD; Shire Beach , MD; Sherry-Ann Brown , MD, PhD; Marcella A. Calton Press, MD, PhD; Martha Gulati, MD, MS; Tamara B. Horwich, MD, MS; Gina P. Lundberg , MD; Erin D. Michos , MD, MHS; Purvi Parwani, MBBS, MPH; Ritu Thamman , MD; Karol E. Watson , MD, PhD; Janet K. Han , MD

BACKGROUND: Social media is an effective channel for the advancement of women physicians; however, its use by women in cardiology has not been systematically studied. Our study seeks to characterize the current Women in Cardiology Twitter network.

METHODS AND RESULTS: Six women-specific cardiology Twitter hashtags were analyzed: #ACCWIC (American College of Cardiology Women in Cardiology), #AHAWIC (American Heart Association Women in Cardiology), #ilooklikecardiologist, #SCAIWIN (Society for Cardiovascular Angiography and Interventions Women in Innovations), #WomeninCardiology, and #WomeninEP (Women in Electrophysiology). Twitter data from 2016 to 2019 were obtained from Symplur Signals. Quantitative and descriptive content analyses were performed. The Women in Cardiology Twitter network generated 48 236 tweets, 266 180 903 impressions, and 12 485 users. Tweets increased by 706% (from 2083 to 16 780), impressions by 207% (from 26 755 476 to 82 080 472), and users by 440% (from 796 to 4300), including a 471% user increase internationally. The network generated 6530 (13%) original tweets and 43 103 (86%) amplification tweets. Most original and amplification tweets were authored by women (81% and 62%, respectively) and women physicians (76% and 52%, respectively), with an increase in original and amplification tweets authored by academic women physicians (98% and 109%, respectively) and trainees (390% and 249%, respectively) over time. Community building, professional development, and gender advocacy were the most common tweet contents over the study period. Community building was the most common tweet category for #ACCWIC, #AHAWIC, #ilooklikecardiologist, #SCAIWIN, and #WomeninCardiology, whereas professional development was most common for #WomeninEP.

CONCLUSIONS: The Women in Cardiology Twitter network has grown immensely from 2016 to 2019, with women physicians as the driving contributors. This network has become an important channel for community building, professional development, and gender advocacy discussions in an effort to advance women in cardiology.

Key Words: social media ■ Twitter ■ Women in Cardiology ■ women

Social media provides an interactive forum for networking, creating new information, and sharing ideas. Twitter is a social media microblogging platform designed for the publication of short text-based messages known as tweets. The use of Twitter

has grown significantly in medicine because of its ability to stimulate discussion about health care and advocacy, disseminate scientific and educational content, and create networking communities for healthcare professionals.^{1,2}

Correspondence to: Janet K. Han, MD, Division of Cardiology, University of California, Los Angeles, Room A2-237 Center for the Health Sciences, 650 Charles E. Young Dr S, Los Angeles, CA 90095-1679. E-mail: janethan@mednet.ucla.edu

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CLINICAL PERSPECTIVE

What Is New?

- The Women in Cardiology Twitter network has grown immensely from 2016 to 2019. Contributions are driven primarily by women physicians, academic women physicians, and medical trainees, with a decline in participation by men over time.
- This global professional network serves as a new and invaluable arena for community building, professional development, and gender advocacy discussions for women in cardiology.

What Are the Clinical Implications?

- Further studies are needed to understand the impact of this social media network on the recruitment, retention, and advancement of women in cardiology.
- Ongoing collaboration and participation by male colleagues in this virtual platform are necessary to encourage the mentorship, promotion, and sponsorship of women cardiologists.

Nonstandard Abbreviations and Acronyms

#ACCWIC	American College of Cardiology Women in Cardiology
#AHAWIC	American Heart Association Women in Cardiology
#SCAIWIN	Society for Cardiovascular Angiography and Interventions Women in Innovations
#WomeninEP	Women in Electrophysiology
WIC	Women in Cardiology

Since 2017, there have been more women matriculants from US medical schools than men.³ However, gender disparities in medical and surgical specialties continue to persist. Cardiology remains underrepresented, with women comprising only 14% of general cardiologists in 2017.⁴ Commonly cited barriers to entry and career advancement for women in cardiology include challenges relating to family planning, professional mentorship, compensation inequity, and gender discrimination.^{5,6} Although social media has pitfalls, including online harassment, dissemination of false information, and privacy concerns, there is growing use of social media to create virtual communities for women physicians to express a vision for their specialties, build their professional reputations, and engage in networking and mentorship beyond

the limits of their home institutions.^{7,8} The use of social media to advance women in underrepresented medical and surgical specialties has shown positive results, but its use by women in cardiology is unknown.⁸ This study seeks to understand the Women in Cardiology (WIC) Twitter network by characterizing its growth, participants, and overall use and discussions.

METHODS

The data that support the findings of this study are available from the corresponding author on reasonable request. The authors had full access to all the data in the study and were responsible for their integrity and data analysis. Six commonly used women-specific cardiology Twitter hashtags were chosen for analysis: #ACCWIC (American College of Cardiology Women in Cardiology), #AHAWIC (American Heart Association Women in Cardiology), #ilooklikeacardiologist, #SCAIWIN (Society for Cardiovascular Angiography and Interventions Women in Innovations), #WomeninCardiology, and #WomeninEP (Women in Electrophysiology). These WIC hashtags were registered with Symplur Signals, a healthcare social media analytics platform that curates all publicly posted data related to official Twitter hashtags. Twitter activity for each hashtag from January 1, 2016, to August 31, 2019, was retrieved on September 23, 2019.

Symplur Signals' database was accessed to determine the total number of users, tweets, and impressions (tweets×number of followers) per hashtag. Users were categorized into professional groups based on information extracted from Twitter biographies, if available. Professional groups included physician, other healthcare professional, patient/advocate, researcher/academic, journalist/media, other healthcare or nonhealthcare individual, provider/research/academic organization, other healthcare or nonhealthcare organization, and unknown. Each user was manually confirmed to identify gender, professional group, and, if pertinent, academic affiliation and trainee status. The institutional affiliation was verified with the user's university or practice affiliated profile on the internet by one of the authors on our study team (K.T.). User geographic location to assess the geographic range of Twitter use over time was also obtained.

Manual tweet analysis was performed for all tweets by a team of 5 independent physicians (N.C., R.H., H.S., S.S., and S.B.) to determine tweet type and tweet content categories. Tweets were categorized as original tweets or amplification tweets, which included retweets with comment, retweets with hashtag or user tag, or direct retweets without

additional comments or tags. Tweet content was determined manually for original tweets, retweets with comment, and retweets with hashtag or user tag, whereas tweet content of direct retweets was categorized on the basis of parent tweet. Tweet content was categorized as educational, professional development, mentorship, gender advocacy, community building, administrative, or other. Educational tweets provide clinical or scientific education related to cardiology. Professional development tweets promote the works and accomplishments of women colleagues and share professional opportunities, such as speaking engagements, grants, or job opportunities. Mentorship tweets promote trainees and include tweets shared by fellows about faculty and mentorship. Gender advocacy tweets unite WIC by sharing experiences and building awareness about issues, such as barriers to entry or retention for women and statistics about women representation in cardiology. Community building tweets highlight social relationships, including photographs at social events or conferences, welcome new members to the cardiology community, and share inspirational messages. Administrative tweets promote events, lectures, and Twitter tutorials. Tweet content categories were developed in reference to publications conducting similar social media-based research and literature describing issues pertinent to women in medicine and cardiology.^{2,5,7,9,10} Content categories were developed before accessing and reviewing Symplur data. Tweets that were blocked, no longer available, or written in a foreign language without translation were categorized as unavailable. Unavailable tweets were not included in content analysis. To verify consistency among the 5 analysts, tweets were selected at random from each analyst, and tweet type and content categorization were verified by a second analyst. If tweet categorization was ambiguous or disagreed upon, these tweets were discussed as a group for selection of the most appropriate category. Retweet numbers for original tweets, retweets with comment, and retweets with hashtag or user tag were obtained during manual review of tweet content from January to June 2020. Because these retweets occurred after our defined study period, author data were unavailable. As tweets are dynamic, continue to accrue over time, and cannot be determined for specific historical time points, retweet numbers were analyzed to reflect the latest retweet volume and to verify the quantitative data provided by Symplur Signals. This accounts for the discrepancy in total tweets between the quantitative and content analyses.

Quantitative and descriptive content analyses were performed. In accordance with the published University of California, Los Angeles, policies,

institutional review board approval for this study was not required.

RESULTS

Tweets, Users, and Impressions

From 2016 to 2019, the WIC Twitter network generated 48 236 tweets and 266 180 903 impressions, with 12 485 contributing users. Over 44 months, tweets increased by 706% (from 2083 to 16 780), impressions increased by 207% (from 26 755 476 to 82 080 472), and users increased by 440% (from 796 to 4300). #ACCWIC generated 29 272 (61%) of all tweets; #WomeninCardiology, 8370 (17%); #ilooklikecardiologist, 6927 (14%); #AHAWIC, 1322 (3%); #WomeninEP, 1301 (3%); and #SCAIWIN, 1044 (2%). #ACCWIC and #WomeninEP metrics increased annually, #AHAWIC and #WomeninCardiology plateaued, and #ilooklikecardiologist and #SCAIWIN decreased (Figure 1). Combined user participation across all hashtags grew annually, with the largest increase in users by 326% between 2016 and 2017. There was a 440% increase in overall users and 471% increase in international users from 2016 to 2019. Countries with significant user growth included Brazil (2800%), Turkey (1300%), Australia (920%), Japan (900%), United States (661%), Canada (641%), and Indonesia (500%) (Figure 2).

Tweet Type

Comparing Symplur Signals' data downloaded on September 23, 2019, with manual data collection between January and June 2020, there were 362 tweets (0.72% of all tweets) that were initially available but became unavailable because of deleted or blocked tweets or inactivated user accounts. An additional 1734 retweets (3.48% of all tweets) were captured on manual analysis. Tweets generated by the WIC Twitter network were primarily amplification tweets, with a smaller proportion of original tweets. From 2016 to 2019, combining all hashtags, 6530 tweets (13%) were original tweets, 37 777 (76%) were direct retweets, 3706 (7%) were retweets with comment, 1620 (3%) were retweets with hashtag or user tag, and 255 (0.5%) were unavailable tweets. #WomeninEP had the largest proportion of original tweets (23%), followed by #SCAIWIN (18%). #ACCWIC, #AHAWIC, #ilooklikecardiologist, and #WomeninCardiology had tweet type distributions that were similar to the overall distribution trend (Figure 3).

Tweet Authors

There were 6359 unique Twitter users that contributed to the WIC Twitter network during the study period.

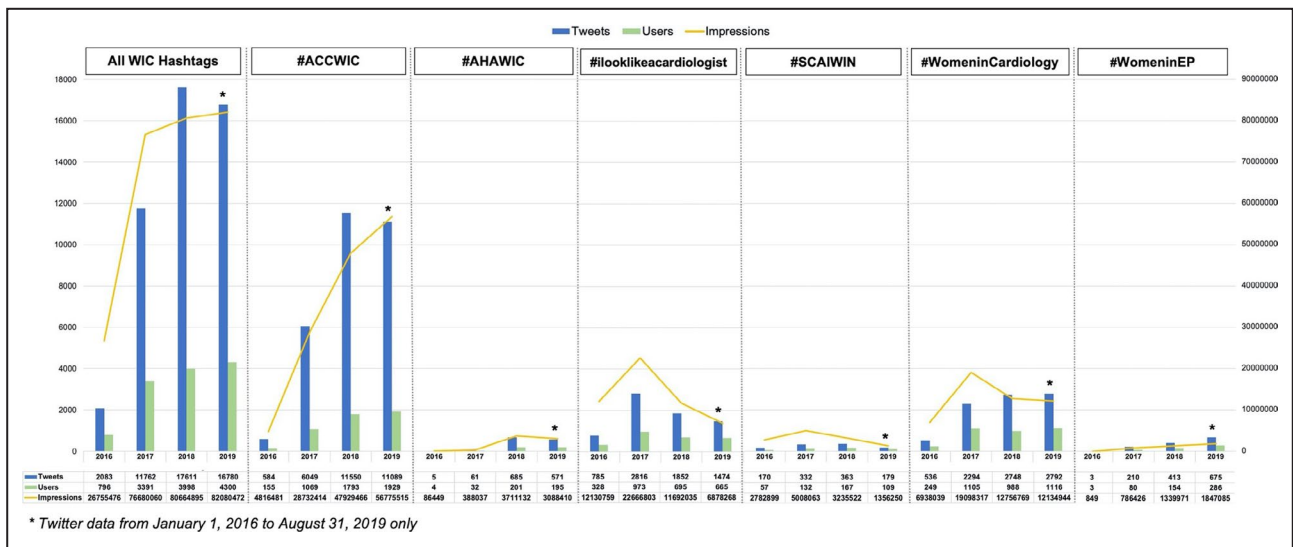


Figure 1. Use trends of Women in Cardiology (WIC) Twitter hashtags, 2016 to 2019. Number of tweets, users, and impressions generated by WIC hashtags, 2016 to 2019. *Twitter data available from January 1, 2019, to August 31, 2019, only. #ACCWIC indicates American College of Cardiology Women in Cardiology; #AHAWIC, American Heart Association Women in Cardiology; #SCAIWIN, Society for Cardiovascular Angiography and Interventions Women in Innovations; and #WomeninEP, Women in Electrophysiology.

Most original tweets were authored by women (5262 tweets or 81%), physicians (5469 tweets or 84%), and academicians (3592 tweets or 55%). Women physicians and women academic physicians authored 4989 (76%) and 3190 (49%) original tweets, respectively, whereas men and men physicians authored 514 (8%) and 478 (7%) original tweets, respectively. Trainees, including medical students, residents, fellows, or graduate students, authored 861 (13%) original tweets. Amplification tweets were also authored primarily by women (25 558 tweets or 62%), physicians (28 318 tweets or 68%), and women physicians (21 647 tweets or 52%). Men and men physicians authored 8692 (21%) and 6607 (16%) amplification tweets, respectively.

From 2016 to 2019, there was an increase in original and amplification tweet authorship by women physicians (14% and 20%, respectively) and academic women physicians (98% and 109%, respectively). Original and amplification tweet authorship by trainees also increased significantly (390% and 249%, respectively). There was a decrease in original tweet authorship by men and men physicians (−10% and −67%, respectively). Amplification tweets by men decreased over time, whereas amplification tweets by men physicians were unchanged (Table).

Tweet Content

Combining all hashtags from 2016 to 2019, community building was the leading category of tweet content, resulting in 2834 (43%) original and 14 924 (35%) amplification tweets. This was followed by professional development, with 1598 (24%) original and 11 771

(27%) amplification tweets, and gender advocacy, with 897 (14%) original and 8942 (21%) amplification tweets. Educational, mentorship, and administrative content each represented <10% of original or amplification tweets. Over the study period, there was a decrease in community building and gender advocacy content among both original and amplification tweets, whereas there was an increase in professional development, educational, and mentorship content (Figure 4). Community building was the most common tweet content for #looklikeacardiologist (42%), #WomeninCardiology (39%), #AHAWIC (37%), #ACCWIC (34%), and #SCAIWIN (29%), whereas professional development was the most common tweet content for #WomeninEP (29%). #WomeninEP had higher proportions of educational content (16% compared with 2%–9%) and lower proportions of community building content (23% compared with 29%–42%) compared with the other 5 hashtags. #looklikeacardiologist had lower proportions of educational content (2% compared with 4%–16%) and higher proportions of community building content (42% compared with 23%–39%) compared with the other 5 hashtags. There were higher proportions of gender advocacy tweets using #looklikeacardiologist (26%), #SCAIWIN (24%), and #WomeninCardiology (23%) compared with #ACCWIC (18%), #WomeninEP (17%), and #AHAWIC (16%) (Figure 5).

DISCUSSION

Our study is the first to report and characterize the recent and robust growth in the WIC Twitter

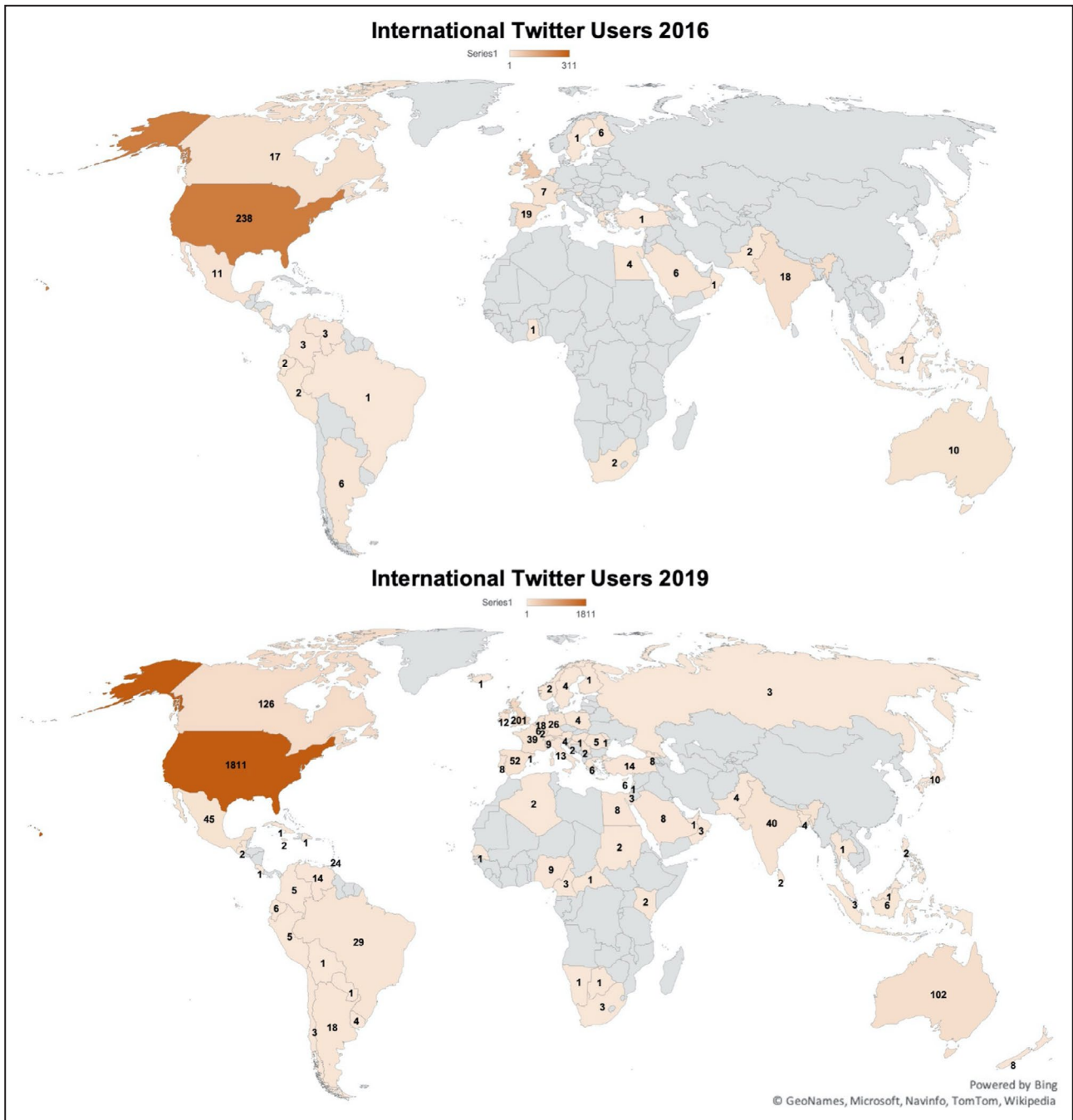


Figure 2. Evolution of international users of Women in Cardiology Twitter hashtags. Comparison of the number of unique international Twitter users by country, 2016 and 2019. Users with geographic location provided in the user’s Twitter biography are included.

network through both quantitative and descriptive content analyses. In our analysis of 6 unique Twitter hashtags, we found a substantial growth in the WIC Twitter network between 2016 and 2019, with an increase in tweets, impressions, and users globally. Contributions to the network were made primarily by women and most significantly by women physicians, with an increase in participation and contribution by academic women physicians over time.

Most notably, discussions created within this virtual network were found to be predominantly related to community building, professional development, and gender advocacy.

Between 2016 and 2019, the 6 studied women-specific cardiology hashtags generated >48 000 tweets, with growth of >700%. These trends are in line with the movement spurred by the creation of the hashtags #ilooklikeasurgeon in 2015 and

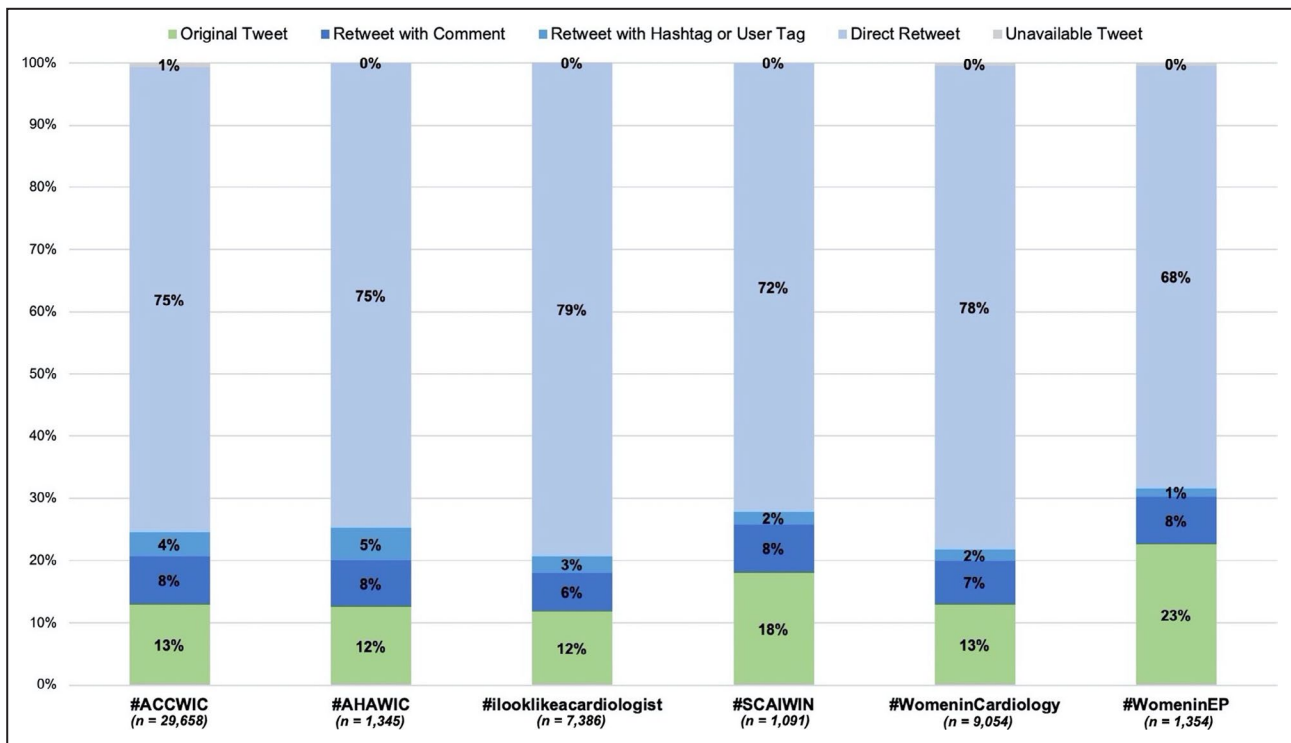


Figure 3. Proportions of tweet types generated using Women in Cardiology (WIC) hashtags, 2016 to 2019.

Proportions of types of tweets generated by each WIC hashtag during the study period. Tweet types include original tweet, retweet with comment, retweet with hashtag or user tag, direct retweet, and unavailable tweet. #ACCWIC indicates American College of Cardiology Women in Cardiology; #AHAWIC, American Heart Association Women in Cardiology; #SCAIWIN, Society for Cardiovascular Angiography and Interventions Women in Innovations; and #WomeninEP, Women in Electrophysiology.

#NYerORcoverchallenge in 2016 by women surgeons. These 2 hashtags were some of the first to build a community of women in medicine on social media, highlighted by the consequential generation of >100 million impressions within 1 year.¹¹ Within cardiology, similar women-specific hashtags were created, with the first being #WomeninCardiology, traced to a tweet in 2013. In a few short years, this community has grown exponentially. During the 4-year study period, the 6 WIC hashtags have generated >266 million impressions. Although impressions are a surrogate marker for overall reach, geolocation of Twitter users revealed a true global expansion of the WIC Twitter network, including in countries where social media platforms are less popular or even censored.

Most of both original and amplification tweets were created by women (81% and 62%, respectively), women physicians (76% and 52%, respectively), and women academic physicians (49% and 31%, respectively). Although it may be anticipated that women drive the conversation for gender-specific hashtags, prior studies have shown that women tend to use social media in private or closed groups because of concerns about confidentiality and harassment.^{12,13} Our study contrasts these prior conclusions on the lack of women's

presence in public platforms. A potential and reasonable explanation is that as women started to contribute more content in the WIC Twitter network, the support within this network self-perpetuated, allowing women a safe and comfortable forum to express opinions and thoughts. The substantial growth in academicians' contribution to the WIC Twitter community suggests there is an acceptance and perhaps even expectation for maintaining an active social media presence. In fact, some academic institutions have developed guidelines for maintaining social media portfolios and have incorporated social media activities in evaluations for academic promotions and tenure.¹⁴

Although participation by women increased substantially, there was an overall decline in participation by men over the study period. Men and men physicians authored a significantly smaller proportion of original tweets (8% and 7%, respectively) and amplification tweets (21% and 16%, respectively). These results highlight a low baseline engagement and downstream decline by male colleagues in using women-specific professional hashtags. There are few research studies on the effects of male advocacy for gender equity in medicine; however, this is well studied in business and political models. Men, who comprise the majority of senior leadership, are less involved in discussions

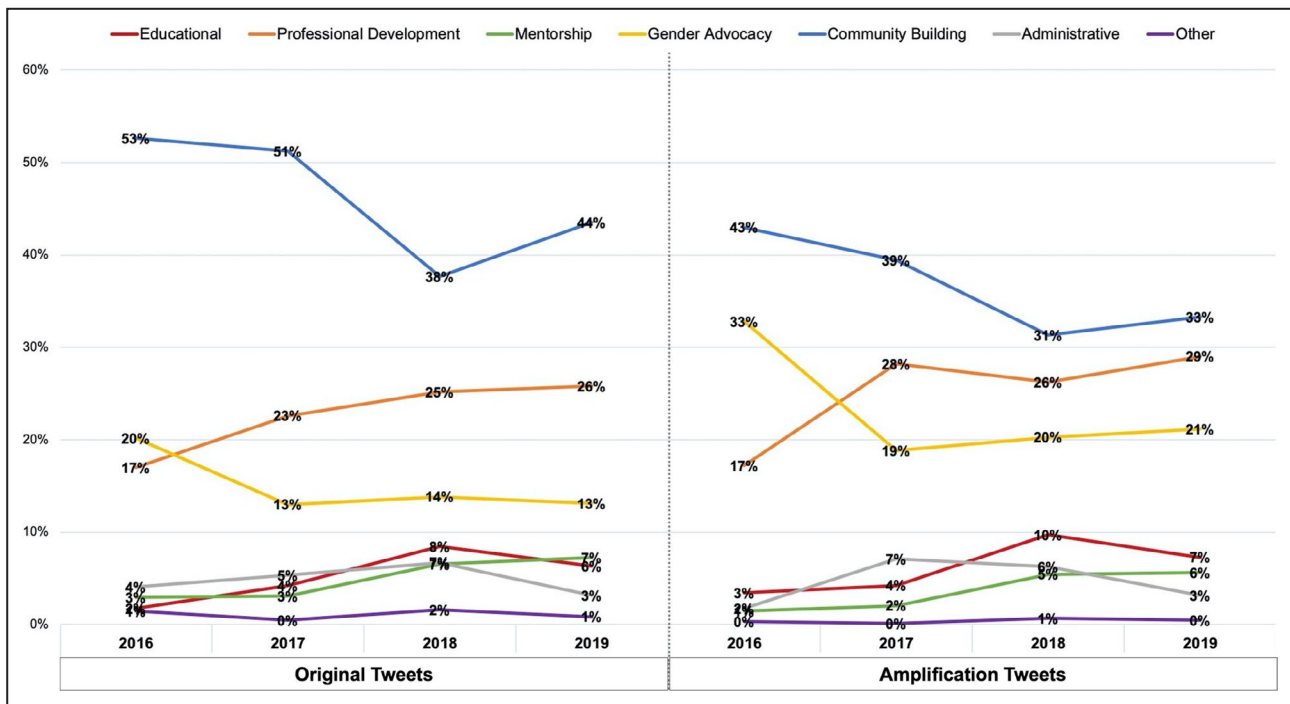


Figure 4. Proportions of tweet content using Women in Cardiology (WIC) hashtags, original and amplification tweets, 2016 to 2019.

Proportions of tweet content generated by all studied WIC Twitter hashtags, showing difference between original vs amplification tweets and difference over time.

about gender parity issues.¹⁵ However, when organizations engage men to become advocates for women through persistent visible support and proactive mentorship and sponsorship, there can be up to 3-fold higher likelihood of change or progress, and a further increase in effective male allyship.¹⁵⁻¹⁷ These findings emphasize the imperative need for increased support and alliance by male colleagues in the advancement of gender equality and equity in cardiology, which could be improved both in person and in the virtual space.

The 6 WIC hashtags have led to the creation of an expansive virtual community with an active and robust social media presence and level of engagement. Over one third of all tweets surrounded community building content, demonstrating that through social media’s dissolution of time and physical constraints, women physicians can readily connect and inspire an inclusive culture in medicine. Professional development was also a predominant theme, comprising over one quarter of all tweets, with a substantial 66% increase in the proportion of professional development tweets over the 4-year study period. The increase suggests that this virtual network may provide women cardiologists with a novel avenue for professional advancement, which has the potential to improve career fulfillment. Women cardiologists have historically expressed lower rates of career satisfaction than men because of unequal compensation, barriers to advancement in academic rank,

and inadequate mentorship.^{9,10,18} Social media offers the potential ability to overcome many of these barriers through access to academic opportunities, such as grants, awards, and speaking engagements, rapid and widespread dissemination of research, and prominent networking connections otherwise unimaginable.^{8,19,20} Our study also suggests that social media creates an opportunity to provide young physicians with positive role models, thus encouraging the recruitment of women trainees into cardiology.²¹⁻²⁴ The 271% increase in the proportion of tweets authored by trainees from our study is a promising supportive observation.

Further analysis of tweet content for each specific WIC hashtag demonstrated interesting differences. #SCAIWIN and #WomeninEP, the 2 subspecialty-specific hashtags, had notably fewer community building tweets compared with others. #WomeninEP was the only hashtag in which the predominant tweet content was not community building, but rather professional development, with a higher percentage of educational tweets compared with other hashtags (16%). Women represent a markedly disproportionate 6% of board-certified electrophysiologists, with only 6% of recently surveyed women fellows intending to pursue this niched subspecialty.^{5,24} Our study showed that #WomeninEP appears to have a conscientiously focused effort on expanding its social media platform by promoting women achievements through

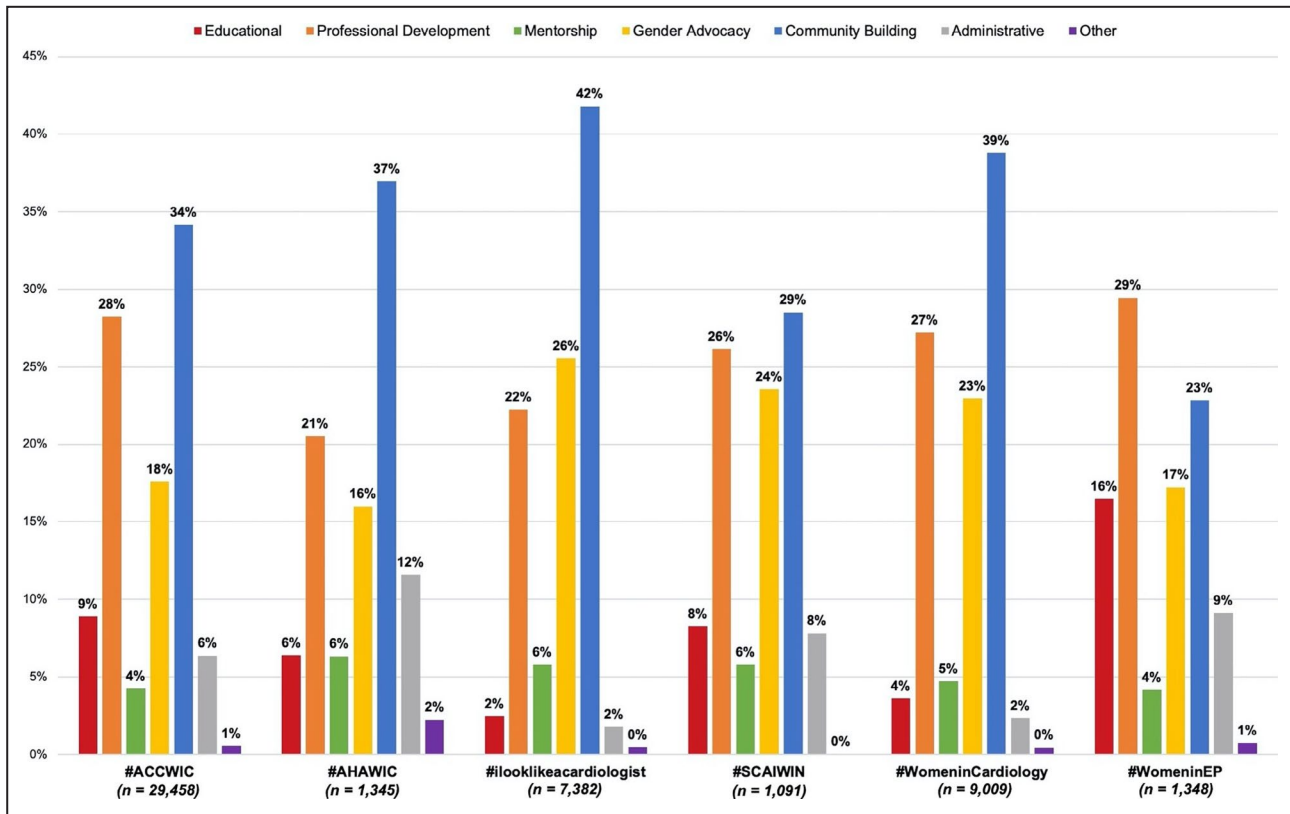


Figure 5. Comparison of tweet content generated by each Women in Cardiology hashtag. Original tweets and amplification tweets combined, 2016 to 2019. Content categories include educational, professional development, mentorship, gender advocacy, community building, administrative, and other. #ACCWIC indicates American College of Cardiology Women in Cardiology; #AHAWIC, American Heart Association Women in Cardiology; #SCAIWIN, Society for Cardiovascular Angiography and Interventions Women in Innovations; and #WomeninEP, Women in Electrophysiology.

professional development tweets and disseminating specialized educational content to increase exposure to electrophysiology. It is also noteworthy that, despite there being a greater proportion of men physician users of #WomeninEP compared with women physician users (28% compared with 26%; Figure S1), the tweet activity by men physicians is notably less (20% tweets written by men physicians compared with 39% by women physicians). This suggests that, despite the larger number of male Twitter users, the nominal number of women physicians are in fact the major drivers behind content generation and advancement of this movement in cardiology.

This study had several limitations. As this is a descriptive study of women in cardiology hashtags, comparisons to social media use among other women physician specialty groups cannot be made. Other social media and community platforms were not studied; thus, findings are limited to the individuals engaged in Twitter. The 6 hashtags studied were selected by the authors to represent the most widely used and specific WIC hashtags for general cardiology and its subspecialties. Not all gender-specific hashtags were represented in our study, and the study was limited to English-language

hashtags. All tweets in the broader WIC Twitter network may not have included hashtags; thus, Twitter activity in this network may be underestimated because of lack of awareness, inaccurate use, or underuse of the studied hashtags. A commonly used hashtag, #WIC, was not included in the study because of the significant cross use by the US Department of Agriculture program for Women, Infants, and Children (WIC), based on our year-specific use analyses. Although #WIC was coreferenced in tweets using our 6 studied hashtags, we were unable to report reliable tweet data for this hashtag alone given its 2 discrete user populations. Our data set represents Twitter activity within our study period and is unable to reflect the current state because of Twitter’s dynamic nature. Author demographic data reflect the author’s specifications in 2020 when the manual review was performed, not at the time the tweet was written. Thus, tweet authors may have had changes in professional title or academic affiliation that we were unable to capture, including moving from trainee to cardiologist. Information on the number of users tagged per tweet and demographics of users tagged was not collected. Last, content categorization of tweets was subject to the authors’ discretion.

Table. Characteristics of Tweet Authorship in the WIC Twitter Network

Author Characteristics	Authorship of All Tweets Between 2016 and 2019, n (%)		Change in Authorship of All Tweets From 2016 to 2019	
	Original Tweets (n=6530)	Amplification Tweets (n=41 344)	% Change in Original Tweets	% Change in Amplification Tweets
Gender				
Men	514 (8)	8692 (21)	-10	-8
Women	5262 (81)	25 558 (62)	15	6
Healthcare stakeholder				
Physicians	5469 (84)	28 318 (68)	-1	15
Nonphysicians	1061 (16)	13 026 (32)	4	-21
Women physicians	4989 (76)	21 647 (52)	14	20
Men physicians	478 (7)	6607 (16)	-67	0
Academic affiliation				
Academic individual	3592 (55)	18 450 (45)	44	73
Academic women physicians	3190 (49)	12 825 (31)	98	109
Trainee status				
Medical trainee	861 (13)	3995 (10)	390	249

Number and proportion of tweets written by each author group. Columns 2 and 3: Number and proportion of original tweets and amplification tweets authored by each author group between 2016 and 2019. Columns 4 and 5: Percentage change in the proportion of original tweets and amplification tweets authored by each author group from 2016 to 2019. WIC indicates Women in Cardiology.

CONCLUSIONS

The WIC Twitter network has grown immensely from 2016 to 2019. The discussions on this social media platform are being driven by women physicians, with a notable growth in the participation of academic women physicians and medical trainees. This unique Twitter network has become a valuable and vital arena for community building discussions, professional development and promotion of women physicians, and advocacy for women in cardiology. To build the community further, it will take the collaboration of our male colleagues, particularly those in leadership roles, to actively participate in this effective global platform to mentor, promote, and sponsor women cardiologists. Future studies to understand the downstream impact of this social media network on the recruitment and retention of women in cardiology, as well as the professional advancement of women cardiologists, are warranted.

ARTICLE INFORMATION

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Affiliations

From the Department of Internal Medicine (N.V.C., K.T., S.B.) and Division of Cardiology, Department of Medicine (R.H., H.S., M.A.C.P., T.B.H., K.E.W., J.K.H.), University of California, Los Angeles, CA; Division of Cardiology, Department of Medicine, Duke University School of Medicine, Durham, NC (S.S.); Cardio-Oncology Program, Division of Cardiovascular Medicine, Department of Medicine, Medical College of Wisconsin, Milwaukee, WI (S.B.); Division of Cardiology, Department of Medicine, University of Arizona College of Medicine Phoenix, Phoenix, AZ (M.G.); Division of Cardiology, Department of Medicine, Emory University School of Medicine, Atlanta, GA (G.P.L.); Division of Cardiology, Department of Medicine, Johns Hopkins School of Medicine, Baltimore, MD (E.D.M.); Division of Cardiology, Department of

Medicine, Loma Linda University Health, Loma Linda, CA (P.P.); and Division of Cardiology, Department of Medicine, Division of Cardiology, Department of Medicine, University of Pittsburgh School of Medicine, Pittsburgh, PA (R.T.)

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Disclosures

Dr Han serves as the social media editor for the *Journal of the American College of Cardiology: Clinical Cardiac Electrophysiology* and is a member of the Heart Rhythm Society Communications Committee. Dr Brown serves on the American College of Cardiology (ACC) Women in Cardiology (WIC) Leadership Council and Communications Working Group and the American Heart Association (AHA) WIC Committee. Dr Lundberg serves as the Social Media Supervisor for the *Journal of the American College of Cardiology: Case Reports* and the Communications Co-Chair for the ACC WIC Leadership Council. Dr Parwani serves as a social media consultant for the *Journal of the American College of Cardiology* and the social media editor for the *Journal of Cardiovascular Magnetic Resonance*.

Supplementary Material

Figure S1

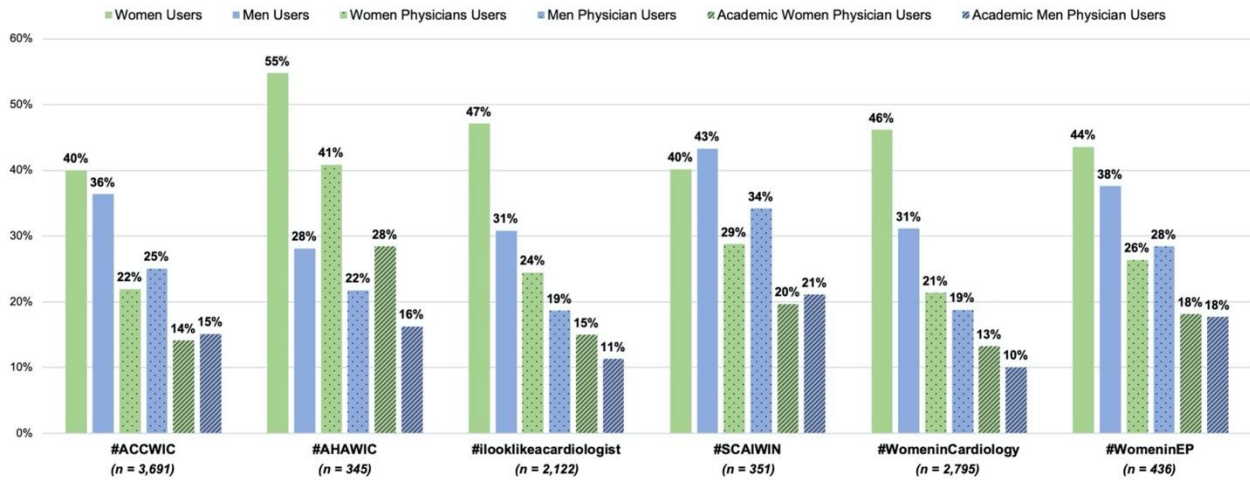
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SUPPLEMENTAL MATERIAL

Figure S1. Characteristics of Women In Cardiology Twitter Users by Hashtag.



Proportion of unique Twitter users by hashtag. User groups include women, men, women physicians, men physicians, women academic physicians, or men academic physicians. A unique user is represented once within a hashtag but may be represented additionally among other hashtags.