

Social Media Network Analysis of Academic Urologists' Interaction Within Twitter Microblogging Environment

Spencer H. Bell,¹ Clara Sun,² Emma Helstrom,¹ Justin M. Dubin,³ Ilaha Isali,⁴ Kirtishri Mishra,⁴ Andrew Gianakopoulos,² Seyed Behzad Jazayeri,⁶ Mohit Sindhani,⁷ Lee Ponsky,⁴ Alexander Kutikov,¹ Casey Seideman,⁸ Andres Correa,¹ Diana Magee,¹ Laura Bukavina^{✉1,3}

¹Department of Urologic Oncology, Fox Chase Cancer Center, Philadelphia, United States ²Case Western Reserve University School of Medicine, Cleveland, United States ³Loyola University, Chicago, United States ⁴Department of Urology, University Hospitals Cleveland Medical Center, Cleveland, United States ⁵Department of Urology, Northwestern University Feinberg School of Medicine, Chicago, United States ⁶Department of Urology, University of Florida, Jacksonville, United States ⁷Indian Institute of Technology, Delhi, India ⁸Oregon Health and Science University, Portland, United States

Abstract

Objective To characterize academic urology Twitter presence and interaction by subspecialty designation.

Methods Using Twitter application programming interface of available data, 94000 specific tweets were extracted for the analysis through the Twitter Developer Program. Academic urologists were defined based on American Urological Association (AUA) residency program registration of 143 residency programs, with a total of 2377 faculty. Two of 3-factor verification (name, location, specialty) of faculty Twitter account was used. Additional faculty information including sex, program location, and subspecialty were manually recorded. All elements of microblogging were captured through Anaconda Navigator. Analyzed tweets were further evaluated using natural language processing for sentiment association, mentions, and quote tweeted and retweeted. Network analysis based on interactions of academic urologist within specialty for given topic were analyzed using D3 in JavaScript. Analysis was performed in Python and R.

Results We identified 143 residency programs with a total of 2377 faculty (1975 men and 402 women). Among all faculty, 945 (39.7%) had registered Twitter accounts, with the majority being men (759 [80.40%] versus 185 [19.60%]). Although there were more male academic urologists across programs, women within academic urology were more likely to have a registered Twitter account overall (46% versus 38.5%) compared with men. When assessing registered accounts by sex, there was a peak for male faculty in 2014 (10.05% of all accounts registered) and peak for female faculty in 2015 (2.65%). There was no notable change in faculty account registration during COVID-19 (2019–2020). In 2022, oncology represented the highest total number of registered Twitter users (225), with the highest number of total tweets (24 622), followers (138 541), and tweets per user per day (0.32). However, andrology (50%) and reconstruction (51.3%) were 2 of the highest proportionally represented subspecialties within academic urology. Within the context of conversation surrounding a specified topic (#aua21), female pelvic medicine and reconstructive surgery (FPMRS) and endourology demonstrated the total highest number of intersubspecialty conversations.

Conclusions There is a steady increase in Twitter representation among academic urologists, largely unaffected by COVID-19. While urologic oncology represents the largest group, andrology and reconstructive urology represent the highest proportion of their respective subspecialties. Interaction analysis highlights the variant interaction among subspecialties based on topic, with strong direct ties between endourology, FPMRS, and oncology.

Key Words

Twitter, social media, sex, specialty, technology, urology

Competing Interests

None declared.

Article Information

Received on October 15, 2022
Accepted on January 18, 2023
This article has been peer reviewed.

Soc Int Urol J. 2023;4(2):96–104
DOI: 10.48083/TKEK6928

Abbreviations

API application programming interface
 AUA American Urological Association
 FPMRS female pelvic medicine and reconstructive surgery
 SoMe social media

Introduction

The use of social media (SoMe), specifically Twitter, as a professional platform is increasingly common among healthcare workers, including urologists[1]. Urology residents, medical students, programs, journals, and faculty have used Twitter to advertise virtual events, gain information for the match process, form mentorships, promote publications, and share clinical information. The circumstances imposed by the COVID-19 pandemic catalyzed the increasing use of Twitter among the urological community[2]. The geographical and physical limitations spurred by the pandemic resulted in both academic programs and students alike having to adopt new approaches for communication with a focus on SoMe.

The dramatic reduction of clinical and research activities within the medical and surgical departments during COVID-19, coupled with virtual electives and conferences, have all posed important implications within academics. Furthermore, the current landscape of Twitter use among academic urology faculty at accredited US institutions has yet to be assessed. Given the heavy reliance on virtual interaction during the pandemic and the active role that SoMe plays, our study aims to characterize the state of Twitter use among current academic urology faculty. As Twitter offers an information-rich reservoir created by the urologic academic community, the interactions among users shape complex network structures that have not been previously evaluated. The aim of our study was to characterize the currently academic urology Twitter presence by sex and specialty. We hypothesize that while urologic oncology represents the total largest number of Twitter participants within urology, there is a growing trend among other subspecialties of urology, with an increasing number of interactions.

Materials and Methods

Data source

Data collection occurred from May 2021 to March 2022. A list of accredited US urology residency programs was pulled from the American Urological Association (AUA). All MD/DO faculty associated with the US urology residency program and academic centers were included in the study. Information including sex, program location, and subspecialty training were

recorded from their respective websites. Faculty Twitter account was verified via a 2-factor verification process (name plus location) in addition to automated Twitter match. Transplant was not included in some analyses because of the low number of participating faculty on Twitter, while fellowship-trained sexual medicine faculty was included in the andrology group.

Collection of Twitter information

Collection of relevant tweets from 2006 until March 2022 was performed. The Twitter streaming application programming interface (API) dataset creation has previously been described[1]. Briefly, tweets were collected using Twitter Streaming API using Python (v3.10.8). All tweets from predesignated academic faculty were used for analysis. In addition, all accounts followed by the user (following), accounts following the user (followers), timelines, and geographic location (when available from Twitter privacy setting) were collected using rtweet (R version 4.2.2). Further information and code regarding extraction of user-specific data can be found here (<https://github.com/ropensci/rtweet/>)[3]. After data preprocessing, relevant tweets were selected and analyzed. Tableau Desktop was fed into CSV and Excel files for data visualization.

Natural language processing (NLP) pipeline

All elements of microblogging, including retweets, likes, followers, following, sentiment, hashtags, and mentions were captured through Anaconda Navigator. Full-text tweets were preprocessed by converting the sentences into words (Tokenization) and removing unnecessary punctuations, tags, and stop words that do not have a specific semantic meaning (“the,” “are”). Preprocessing was done using the Natural Language Toolkit (NLTK) on Python (v3.10.8).

Sentiment analysis

Following processing of tweets and removal of duplicates and unnecessary punctuations, all tweets were split into 3 data frames based on sentiment (neutral, negative, and positive). Sentiment analysis refers to identifying and classifying tweets that are expressed in text using the machine learning sentiment analysis model to compute users' perception. Sentiment analysis was done using (<https://github.com/yalinyener/TwitterSentimentAnalysis>) package in Python (v3.10.8).

Twitter interaction analysis

While the rtweet package allows for downloading tweets and stream API, extraction of tweets relevant to a topic at hand (designated around a hashtag #), followed by building of interaction centered around users (nodes), was performed via twinetverse in R and is freely available here (<http://graphtweets.john-coene.com/>). Each interaction consists of a source and a target; in other words, the source is the screen name

(faculty), the user who posted the tweet, while target is the users who were tagged or interacted with the tweet. This type of analysis allowed for interaction factor between subspecialties (grouped faculty) based on topic of discussion. Although we chose to group based on urologic subspecialty, this analysis can be user specific or topic specific. Interaction analysis was depicted as the number of interactions between the subspecialties only, and no regression analysis was performed to test for statistical significance as interaction is dependent on the topic.

Statistical analysis

Demographics were summarized using descriptive statistics. The categorical variables are presented as counts and percentages and were compared using a chi-square test. The continuous variables are expressed as means (standard deviation [SD]) or medians (interquartile range [IQR]). All statistical analyses were conducted by a statistician (M.S.) and cross referenced by a physician (L.B.) using R version 4.0.4. All tests were 2-sided with statistical significance defined by $P < 0.05$. All visualizations were performed by Tableau Desktop and Corel Draw.

Results

Demographics

We identified 143 residency programs through the AUA website with a total of 2377 faculty (1975 men and 402 women). Among all faculty, 945 (39.75%) had registered Twitter accounts, with the majority being men (760 [80.42%] versus 185 [19.58%]). However, while the overall number of male academic urologists was higher, proportionally, female urologists were more likely to have a registered Twitter account (46 % versus 38.5%) (Figure 1).

The percentage of new Twitter accounts created from 2006 to October 2021 stratified by sex was similarly assessed (Figure 1). Overall, there were more male than female accounts registered for every year, with a peak for male faculty in 2014 (10.05% of all accounts registered) and peak for female faculty in 2015 (2.65% of all accounts registered). Conversely, there was no notable change during the COVID-19 (2019–2020) peak epidemic.

Faculty fellowships were categorized into andrology, endourology, female pelvic medicine and reconstructive urology (FPMRS), general, oncology, pediatrics, reconstruction, robotics, and transplant. Consistent with AUA census, there are fewer female urologists across all fellowships compared with male urologists. Sex differences among fellowship training and SoMe use were also evident. For female faculty, andrology (60%), reconstruction (60%), and endourology (58.06%) had the highest proportion of Twitter representation (Figure 1).

Among men, andrology (48.59%), reconstruction (48.56%), and oncology (48.33%) had the highest proportion of registered user accounts. General urology for both female (19.67%) and male faculty (17.86%) had the lowest Twitter representation (Figure 1). When comparing female and male Twitter representation within each specialty, female faculty had the highest representation in female (45.77%), pediatric (28.29%), and reconstructive (24.59%) urology, while male faculty had the highest representation in oncology (93.30%), and robotics (91.85%) (Figure 1).

Program representation

When assessing program representation, The University of Colorado (69.57%), Mayo Clinic Rochester (67.86%), and Case Western Reserve (65.22%) had the most faculty on SoMe, proportional to the size of their program (Supplementary Appendix Figure S1). The 5 cities with the highest overall Twitter representation were Philadelphia (52; 5.50%), New York (5.50%), Cleveland (43; 4.55%), New Hyde (34; 3.59%), and Chicago (32; 3.38%) (Supplementary Appendix Figure S1).

Twitter activity

The top 5 words by occurrence since 2006 were “urology”, “dr”, “great”, “aua”, and “cancer” (Supplementary Appendix Figure S1). The most frequently used hashtags used by academic faculty users on Twitter were #prostatecancer (5369), #urology (3851), #bladdercancer (3122), and #covid19 (2839) (Supplementary Appendix Figure S1). The top 3 mentions were @daviesbj (14 159), @amerurological (12 730), and @urogeek (5124). Overall, 45.72% of all tweets were considered positive, while 43.64% were neutral, and 10.64% were negative.

Sex-specific differences were observed. Although the top 2 hashtags among female academic urologists were #urology (1112) and #covid19 (801), women were more likely to mention other female urologists including @loebstacy (1052), @ashleywinter (741), and caseyseidman (544) compared with male faculty (Supplementary Appendix Figure S1).

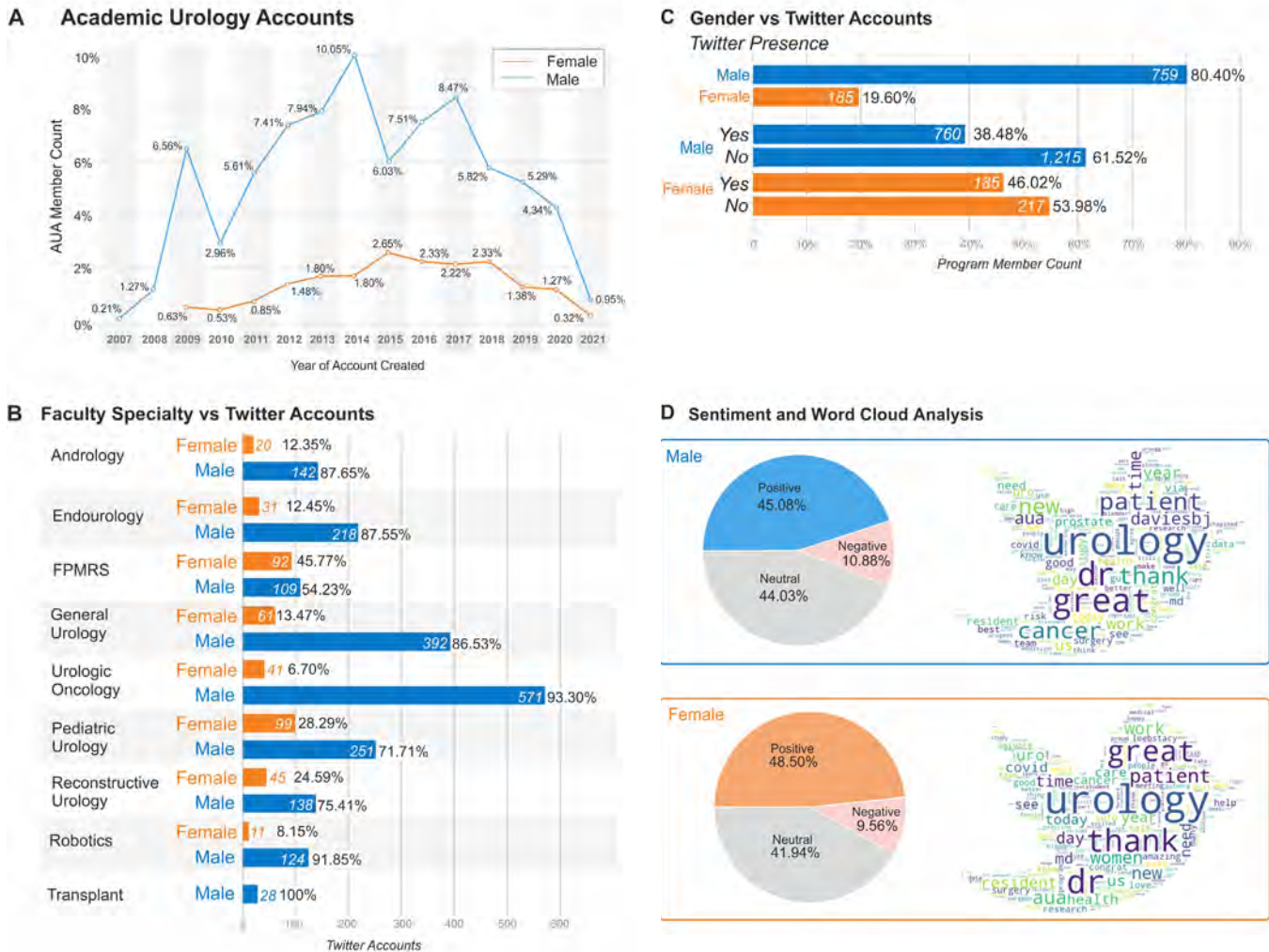
The “sentiment” distribution across tweets by male and female faculty was different, with female faculty noted to tweet more “positively” than male faculty (48.50% versus 45.08%), although the difference was not statistically significant (chi-square, $P = 0.4$) (Figure 1).

Subspecialty analysis

As previously hypothesized, urologic oncology represented the largest overall subspecialty on Twitter, with the total number of active members of 225. The subspecialty also represented the highest tweets per day per user (0.32) and total tweets per day (73.72) and the highest total followers (333 951) and likes (143 261). Andrology and pediatric urology represented the second-highest group among the subspecialties for tweet

FIGURE 1.

General Twitter presence and number of user accounts from 2007 to 2021. Academic Urology Twitter presence is shown by number of Twitter accounts by year (A) stratified by male vs female. In addition, total Twitter academic urology presence is broken down by specialty and gender (B). Overall academic Twitter presence based on gender can be seen in C, showing overall percentage of Twitter accounts (top) and broken down by proportion of all academic urologist (bottom). (D). Sentiment analysis designated as neutral, negative or positive from each users' tweets, with birdgram representative of most commonly utilized words within the tweets corresponding to the size of the word



per user per day (0.29) and similar number of followers (66757 versus 66425); however, pediatric urology was more likely to retweet a post than andrology (1433124 versus 448264) (Figure 2).

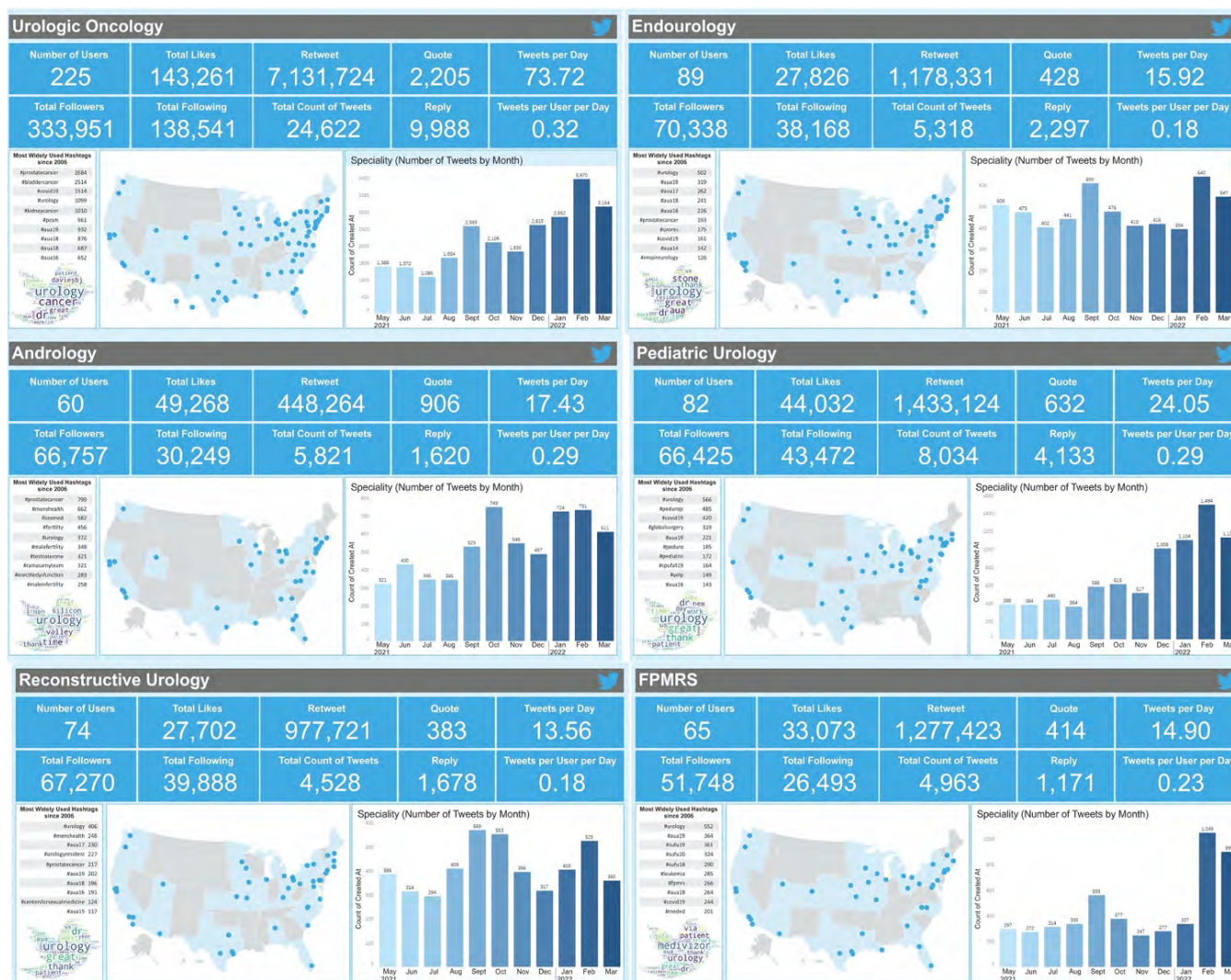
When assessing temporal trends across specialties by month and day, urologic oncology represented the highest tweet count overall, with peaks in September 2021 (529), January 2022 (724), and February 2022 (731). January and February corresponded to similar trends among other specialties likely reflecting AUA match, while many specialty meetings corresponded to peaks in activity. Overall, Monday represented the lowest activity day on average, with Twitter activity increasing from Thursday and peaking on Friday night (Figure 3).

Twitter network interaction analysis among subspecialties

We assessed urology subspecialty interaction on Twitter by counting the total number of interactions between specialties centered around the hashtags: #aua21, #auamatch, and #urosome. Although any hashtag can be used for the interaction analysis, we chose these particular “specialty neutral” hashtags to visualize active direct communication. While urologic oncology consistently interacted with other subspecialties most frequently due to the total number of participants within urologic oncology (ie, 39 interactions with FPMRS), when assessing global proportional interaction, FPMRS represented the most diverse interaction network.

FIGURE 2.

Twitter profiles of urologic subspecialties on Twitter. Hashtag results based on 2006 to present analysis, remainder of the reported features reflective of May 2021 to March 2022 data



As seen in Figure 4, conversations focused within a subspecialty were also more likely to be seen within urologic oncology (visualized as blind ending blue node). While this interaction improved with #urosoma and #auamatch, the interactions as seen in Figure 4 are topic dependent, with more interactions seen between andrology and urologic oncology with #urosoma than the other 2 topics. Overall, pediatric urology and FPMRS did highlight more interactive ties compared with other subspecialties.

Discussion

The steady increase in Twitter representation among academic urologists since 2006 reflects the increasing awareness of Twitter as a means of academic representation and promotion among individual programs and faculty. A recent study has also found increasing

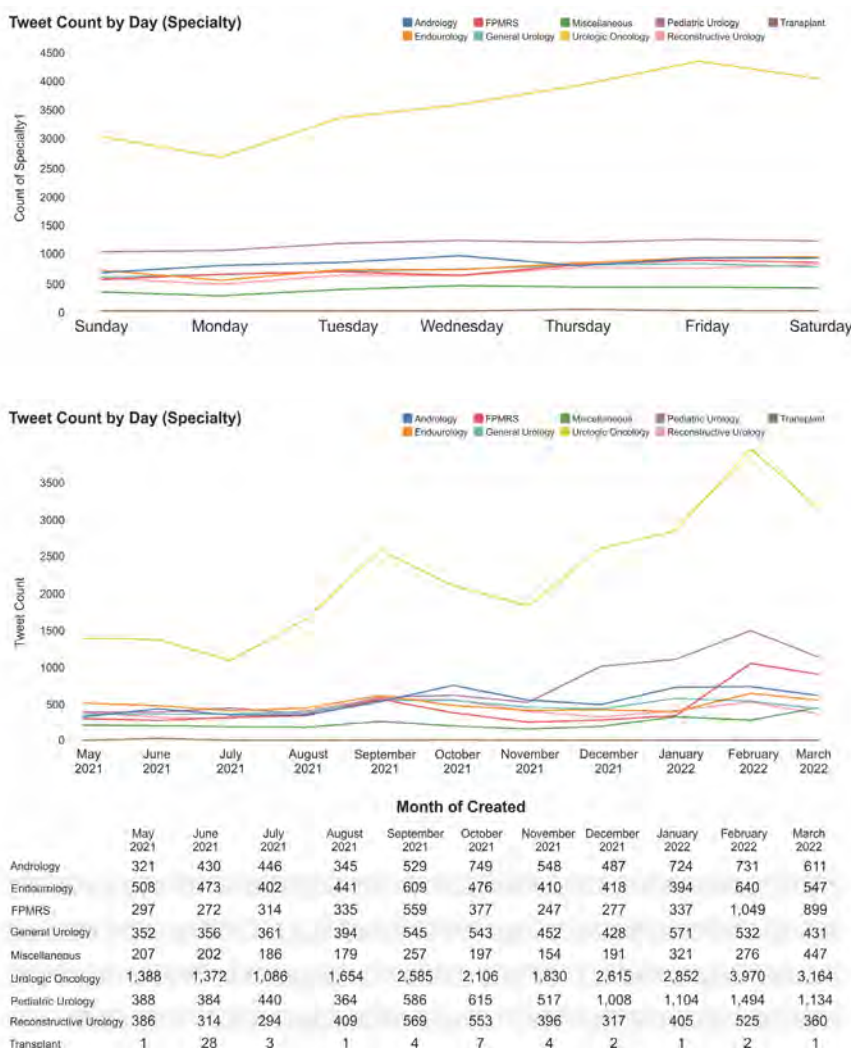
Twitter usage among urologists, prompted by different incentives. Urologists in the US and Canada who were in lower academic ranking and had higher H-indices were more likely to have Twitter accounts[4].

The challenges imposed by COVID-19 limited in-person interactions, forcing the medical community to embrace other forms of communication. Although we did not see any notable changes in the number of registered accounts for faculty during COVID-19 (2019–2020), there was a significant jump in urology program account creation in 2020, the largest increase since 2009[5].

While the majority of Twitter representation is largely skewed toward male faculty, we found a steady increase in female faculty representation across all urology subspecialties over the past 16 years. Proportionately,

FIGURE 3.

Temporal distribution of online Twitter activity by day and month, further categorized by sub-specialty within urology



more female urologists use Twitter. This might be an effort of female urologists to build their professional reputation and to inspire other aspiring female surgeons. Besides the goal of improving healthcare, Twitter presence has been shown to increase industry support, with surgeons with an active Twitter account receiving 1.7 times the amount in payments compared with surgeons without an active account. Furthermore, among Twitter users, those with 321 to 172 000 followers received 4.7 times and 9.5 times the amount in payments compared with those with 0 to 80 followers[6].

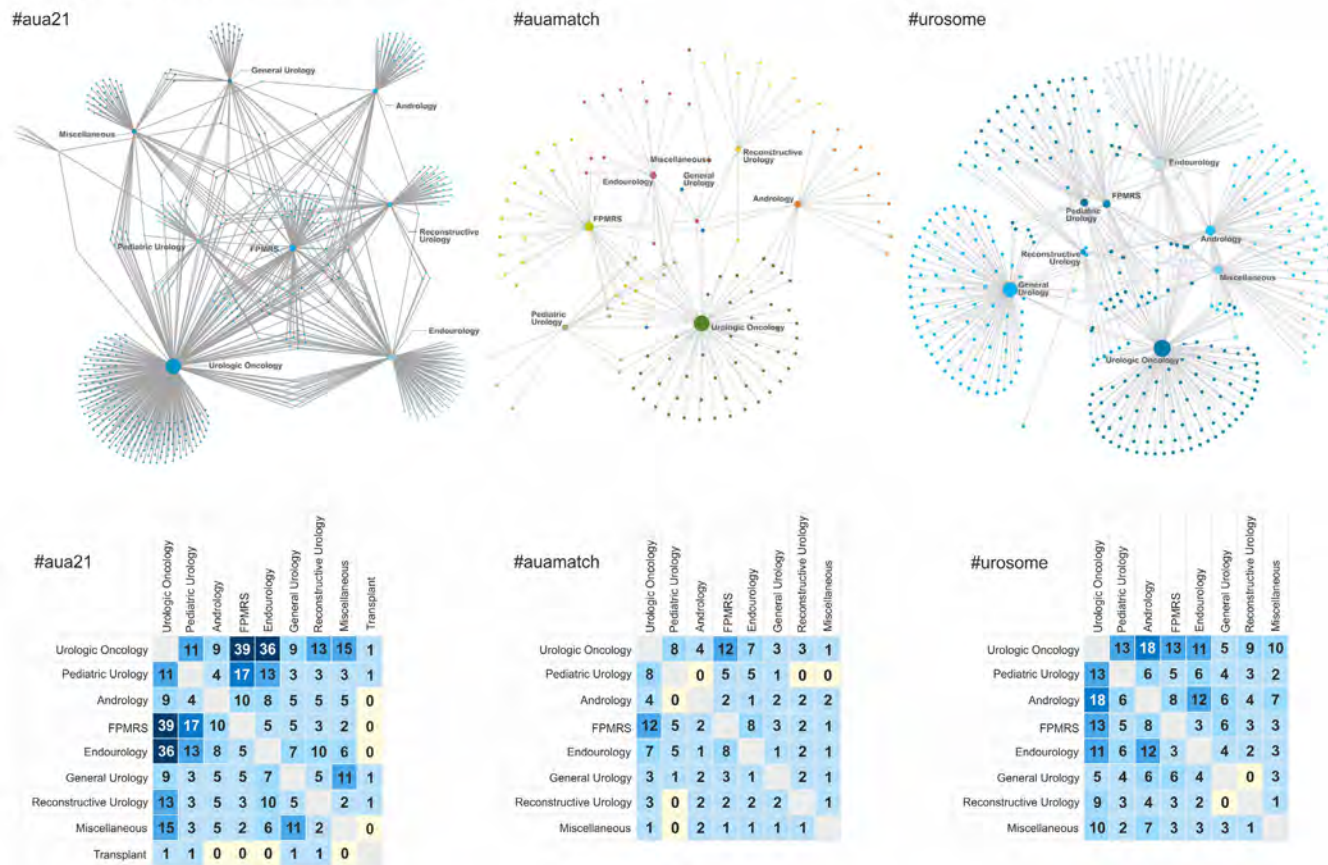
One of the top hashtags used by female faculty, but not in the top for male faculty, was #ilooklikeasurgeon. The sex differences in Twitter activity highlight how academic female urologists use SoMe as a platform for advocacy and cultural change initiatives. Women were

also more likely to mention or tweet to a male and female urologist on Twitter, while male academic urologists limited their interaction to male colleagues as evidenced by top mentions. This finding is not unique to urology. In a recent study by Zhu et al., which evaluated a total of 3148 health services researchers on Twitter, women were more likely to follow other women (54.8% of users followed by women were women, whereas 42.6% of users followed by men were women)[7]. Academic urologists fellowship trained in andrology, reconstruction, endourology, and oncology had the most Twitter representation. This is supported by data previously published, showing that physicians in the US and Canada trained in urological oncology, minimally invasive urology, and endourology were more likely to have Twitter accounts[4]. One possible explanation for the high percentage of andrology faculty could be attributed to

FIGURE 4.

Interaction analysis based on subspecialty direct interaction with others on three different topics including #aua21, #auamatch, and #urosome. Interaction tables represent the number of direct conversations between members of each subspecialty focused on the topic at hand

Urology Specialty Interaction on Twitter



the stigma inherent to the topics within the subspecialty, such as sexual health and male infertility. Because these conversations may be difficult for patients to discuss openly, andrology faculty are likely using SoMe as an advocacy platform.

The most frequently used hashtags by academic urologists were dedicated hashtags created for annual AUA conferences. These hashtags not only organize posts associated with a certain conference but also reflect the increasing use of Twitter during medical conferences. In a 2017 survey of AUA members, a third of the 1280 respondents with SoMe accounts reported following a medical conference virtually[8]. The 2018 AUA annual conference had a significant, 5-fold increase in Twitter posts compared to 2013[9]. Another hashtag that dramatically increased in occurrence was #covid19. In just over 2 years, #covid19 surpassed others as one of the top 5 most frequently used hashtags in the past 16 years. This likely reflects the increased consumption of SoMe

as a source of information on COVID-19. Valdez et al. showed that Twitter volume increased consistently from early to late March 2020, around when COVID-19 was declared a global pandemic[10].

Our study is unique in that compares direct interaction among subspecialties within academic urology on Twitter. While previous research has focused mainly on trends of utilization and growth, our innovative analysis fostered by information networks and a novel API network, highlights the communication and engagement among the subspecialties. Based on our findings, we can establish that virtual interaction on Twitter is dependent upon the topic; however, strong intersubspecialty ties are seen from FPMRS and pediatric urology. As we previously mentioned, while it may seem that urologic oncology by number alone had the highest level of interaction, proportionally, FPMRS and pediatric urology were more likely to engage other subspecialties. It is unclear why this network structure exists,

and the implications of this type of interaction; however, a higher level of interaction is more likely to spread to other networks and enhance the spread of information (ie, reach more users).

Our study is not without limitations. We analyzed only academic urologists. Thus, urologists who work in private practice or other non-academic institutions were not able to be accounted for. There are many urologists on social media who were not included in the analysis but represent an integral role in advocacy and growth of urologic knowledge (eg, Ashley Winter). Furthermore, faculty designation to subspecialty was based on urologists' academic institution information, and while most were able to be categorized into a subspecialty, the process was dependent on the accuracy of information listed by the institution.

References

1. Bukavina L, Dubin J, Isali I, Calaway A, Mortach S, Loeb S, et al. Twitter footprint and the match in the COVID-19 era: understanding the relationship between applicant online activity and residency match success. *Urol Pract.*2022;9(4):331–339. doi: 10.1097/UPJ.0000000000000306.
2. Prunty M, Rhodes S, Mishra K, Gupta S, Sheyn D, Ponsky L, et al. Female authorship trends in urology during the COVID-19 pandemic. *Eur Urol.*2021;79(2):322–324. doi: 10.1016/j.eururo.2020.11.017. PMID: 33250302.
3. Kearney MW. rtweet: collecting and analyzing Twitter data. *J Open Source Softw.*2019;4(42):1829. doi: 10.21105/joss.01829.
4. Chandrasekar T, Goldberg H, Klaassen Z, Wallis CJD, Leong JY, Liem S, et al. Twitter and academic urology in the United States and Canada: a comprehensive assessment of the Twittersverse in 2019. *BJU Int.*2020;125(1):173–181. doi: 10.1111/bju.14920. PMID: 31602782.
5. Manning E, Calaway A, Dubin JM, Loeb S, Sindhani M, Kutikov A, et al. Growth of the Twitter presence of academic urology training programs and its catalysis by the COVID-19 pandemic. *Eur Urol.*2021;80(2):261–263. doi: 10.1016/j.eururo.2021.05.002. PMID: 34006446.
6. Storino A, Vigna C, Polanco-Santana JC, Park E, Crowell K, Fabrizio A, et al. Disparities in industry funding among colorectal surgeons: a cross-sectional study. *Surg Endosc.*2022;36(9):6592–6600. doi: 10.1007/s00464-022-09062-8. PMID: 35103858.
7. Zhu JM, Pelullo AP, Hassan S, Siderowf L, Merchant RM, Werner RM. Gender differences in Twitter use and influence among health policy and health services researchers. *JAMA Intern Med.*2019;179(12):1726–1729. doi: 10.1001/jamainternmed.2019.4027. PMID: 31609393.
8. Loeb S, Carrick T, Frey C, Titus T. Increasing social media use in urology: 2017 American Urological Association survey. *Eur Urol Focus.*2020;6(3):605–608. doi: 10.1016/j.euf.2019.07.004. PMID: 31351900.
9. Ho P, Margolin E, Sebesta E, Small A, Badalato GM. #AUAMatch: the impact of COVID-19 on social media use in the urology residency match. *Urology.*2021;154:50–56. doi: 10.1016/j.urol.2021.05.019. PMID: 34033828.
10. Valdez D, Ten Thij M, Bathina K, Rutter LA, Bollen J. Social media insights into US mental health during the COVID-19 pandemic: longitudinal analysis of Twitter data. *J Med Internet Res.*2020;22(12):e21418. doi: 10.2196/21418. PMID: 33284783.

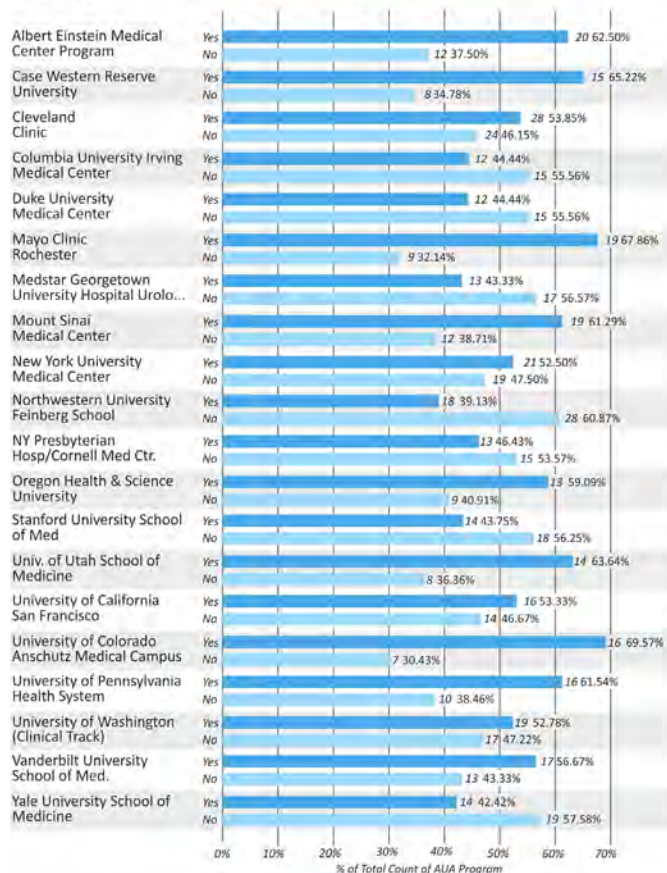
Conclusion

Our research indicated that there is a growing representation of women in the field of academic urology on the social media platform Twitter. This presence offers opportunities for enhanced communication and connection within the field. Furthermore, the study revealed variations in interactions between various subspecialties within urology, with FPMRS and pediatric urology found to have a notable higher level of intersubspecialty engagement compared with other subspecialties.

SUPPLEMENTARY APPENDIX FIGURE S1.

AUA programs faculty Twitter presence, listing of top 10 programs with percent of total faculty (A), as well as total number of registered academic Twitter accounts by city (B). C-D representing overall, male and female specific hashtags and mentions from 2006 to present by faculty, with overall sentiment analysis shown in D and most commonly utilized words (E)

AUA Programs vs Twitter Accounts (Top 20)

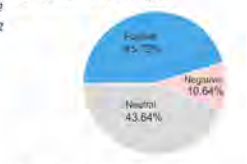


Most Widely Used Hashtags and Mentions since 2006 Overall		Most Widely Used Hashtags and Mentions since 2006 Male		Most Widely Used Hashtags and Mentions since 2006 Female	
#prostatecancer	5369	#prostatecancer	4557	#urology	1112
#urology	3851	#bladdercancer	2844	#covid19	801
#bladdercancer	3122	#urology	2736	#prostatecancer	799
#covid19	2839	#covid19	2037	#aua19	791
#aua19	2461	#aua19	1667	#sexmed	644
#aua18	2032	#aua18	1509	#aua18	521
#aua17	1844	#aua17	1453	#looklikeasurgeon	412
#aua16	1553	#aua16	1251	#aua17	378
#urosome	1551	#urosome	1212	#meded	367
#kidneycancer	1225	#kidneycancer	1141	#sufu19	360
@daviesbj	14159	@daviesbj	13451	@amerurological	2763
@amerurological	12730	@amerurological	9960	@loabstacy	1052
@urogeek	5124	@uretericbud	4850	@swiuiorg	1030
@uretericbud	5015	@urogeek	4795	@mayourology	984
@canesdavid	4811	@canesdavid	4657	@ashleygwinter	741
@chpinmd	4553	@chpinmd	4278	@daviesbj	705
@dr_coops	3906	@medivitor:	3791	@sufuorg	696
@medivior:	3792	@dr_coops	3729	@mayoclinic	637
@uroegg	3655	@uroegg	3531	@pgargollo	551
@wandering_gu	3643	@wandering_gu	3477	@caseyseidemanmd	544

B City vs Twitter Accounts (Top 10)



D Sentiment Analysis



E Word Cloud Analysis

