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Characterization of the #Radiology Twitter Conversation During the Global COVID-19 Pandemic

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A B S T R A C T

Objective: To assess the #Radiology conversation on Twitter social media platform during the COVID-19 pandemic.

Materials and Methods: From February 1 to December 31, 2020, all tweets with a #Radiology hashtag were identified using the healthcare social media analytics tool, Symplur Signals. Data collected included number of tweets, retweets, impressions, links, and user characteristics. Data were stratified by the presence of a COVID-19-related keyword, and a social media network analysis was further performed.

Results: Of the 68,172 tweets, 10,093 contained COVID-19 content from 2809 users generating 65,513,669 impressions. More tweets with COVID-19 content contained links than without (P < 0.01). Network analysis demonstrated most users were physicians (48.10%), authoring the most tweets (40.38%), using the most mentions (32.15%), and retweeting the most (51.45%). The most impressions, however, were by healthcare organizations not providing clinical care (20,235,547 impressions, 30.89%). Users came from 80 countries, most from the United States (29.3%) and the United Kingdom (8.6%). During early March, COVID-19 dominated the #Radiology conversation, making up 54.67% of tweets the week of March 14 and 64.74% of impressions the week of March 21 compared to 13.97% of tweets and 16.76% of impressions in the remainder of the study period (P < 0.01). There was an influx of new users to the #Radiology conversation during this time period with more users tweeting about COVID-19 than not (P < 0.01).

Conclusion: Discussion of COVID-19 in the #Radiology community increased significantly during the early weeks of the pandemic. Real time sharing and collaboration proved a useful tool when rapid information dissemination was needed to manage an emerging pathogen.

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Introduction

Use of social media by healthcare providers has increased tremendously during recent years, changing how healthcare providers interact with colleagues and expanding both educational and networking opportunities for all. Multiple studies have discussed the impact of social media on the medical community in a variety of avenues such as academic scholarship, healthcare organizations, medical journal operations, medical professional meetings, education, and professional networks for mentorship and collaboration. The global coronavirus (COVID-19) pandemic emerged in China in December 2019 and at the time of this paper, COVID-19 infections have reached nearly 84 million with over 1.8 million deaths reported. With a new, rapidly spreading virus, information guiding practice changes daily and information dissemination has become paramount to providing the most up to date patient care. In the early days of the pandemic, data guiding practice arose from anecdotal case descriptions, often not yet published in journals and only available through social media channels.

Twitter hashtags are similar to keywords in a conversation and enable a user to narrow the focus of content in a tweet. The hashtag #Radiology was established in 2010 and now has over 1,000,000 total tweets. In fact, the number of tweets has increased rapidly over the last ten years now with approximately 400 tweets per day. Utilizing social media, information can be shared and collaboration can occur rapidly in real time without the delay that can be caused with journal peer review and publication. Once data were collected and analyzed, the resulting publications can be distributed and amplified rapidly via social media outlets. The aim of this study is to describe global collaboration and rapid information dissemination via the social media platform Twitter in the radiology community during the ongoing global pandemic.

Methods

Study Design and Data Collection

This study did not require institutional board approval. Data was available to the public on the online platform Twitter. We performed a retrospective search utilizing the Hashtag Finder application of Symplur Signals (Symplur, LLC, Upland, CA), a social media analytics tool for healthcare to identify all tweets including the #Radiology hashtag on Twitter between February 1, 2020 to December 31, 2020. After extracting all tweets containing #Radiology during the study period, tweets containing both #Radiology and a COVID-19-related keyword were aggregated. COVID-19 keywords included “COVID19, COVID, corona, coronavirus, pandemic, SARSCOV2, COVID-19.”
Data collected included number of tweets, retweets, impressions, links, hashtags, and user characteristics during the study period. Impressions represent the number of total possible views for each tweet and are calculated by multiplying the number of followers for every participant by the sum of the number of tweets. Stakeholder type definitions are summarized in Appendix 1. Stakeholder types categorized by Symplur as spam or unknown were excluded before analysis. A single user can be classified as multiple stakeholder types, for example a physician who engages in research can be classified as a doctor and researcher/academic.

### Data Analytics and Statistics

Methods of engagement with other users, as defined by Twitter, include retweets and mentions. A retweet is a reposting of an original tweet intended to amplify the tweet message. Mentions call out a specific user in a tweet, notifying that user of the original author’s message. Special content such as media and links can also be embedded in individual tweets. Retweets, replies, mentions, and use of media and links metrics were elucidated and analyzed. Information was also collected about the most popular tweets, hashtags, and links in tweets containing both #Radiology and COVID-19 content.

Furthermore, a social media network analysis was performed to characterize the relationships between specific Twitter users engaging with both #Radiology and COVID-19 content. In addition, we used Twitter geolocation to determine the global and national geographic distribution for users tweeting both #Radiology and COVID-19 related content. Categorical data were reported as relative frequencies (%) and analyzed by chi-square test. A two-tailed P-value of less than 0.05 was considered statistically significant. The analysis was performed using SAS 9.4 (SAS Institute Inc, Cary, NC).

### Results

There were a total of 68,172 tweets, including 10,093 with COVID-19 content during the study time period from 2809 users generating 65,513,669 impressions (Table 1). Most of the digital footprint was composed of retweets rather than original tweets with 48.8% of tweets in the #Radiology conversation being retweets and 51.0% of tweets in the #Radiology with COVID-19 content being retweets.

### Tweet Content

More tweets with COVID-19 content contained links than tweets without (68.1% vs 58.8%, P < 0.01). The top links were educational webinars, informational sites and journal articles (Table 2). The top shared links were from individual users or from established medical advocacy/support organizations and contained open-access resources. The most shared hashtag was #COVID19 (57.56%) followed by #coronavirus (10.88%) (Table 3). The most popular tweets discussed representative cases, literature regarding characteristic findings and appropriate imaging choice for diagnosis. The 10 most popular

### Table 1

Summary of #Radiology Twitter conversation with and without COVID-19 content

|                      | #Radiology with COVID-19 content | #Radiology |
|----------------------|----------------------------------|------------|
| Total Tweets         | 10,093                           | 68,172     |
| Tweets with Mentions | 7223                             | 47,945     |
| Tweets with Links    | 93,954                           | 58,840     |
| Tweets with Media    | 5522                             | 35,991     |
| Retweets             | 5149                             | 33,275     |
| Tweets with Replies  | 148                              | 2131       |
| Users                | 2,809                            | 8672       |
| Impressions          | 65,513,669                       | 367,780,075|

### Table 2

Top 10 links shared with #Radiology containing COVID-19 content

| Rank | Shares | URL                                                                 | Title |
|------|--------|----------------------------------------------------------------------|-------|
| 1    | 74     | https://pubs.rsna.org/doi/10.1148/radiol.2020201365                 | The Role of Chest Imaging in Patient Management during the COVID-19 Pandemic: A Multinational Consensus Statement from the Fleischner Society |
| 2    | 50     | https://rsna.webex.com/mw3300/mywebex/default.do?nomenu=true&steurl=rsnakowrsna&service=6&rnd=0.9835078540188275&maint_url=https://pubs.rsna.org/doi/10.1148/radiol.2020201237 | RSNA COVID-19 Informational Webinar |
| 3    | 42     | https://www.escardio.org/Education/COVID-19-and-Cardiology   | COVID-19 and Cardiology |
| 4    | 36     | https://pubs.rsna.org/doi/10.1148/radiol.2020201183                 | 3D CT of Novel Coronavirus (COVID-19) Pneumonia |
| 5    | 34     | https://www.rsna.org/2019-ncov                                    | 2019 Novel Coronavirus (2019-ncov) |
| 6    | 32     | https://pubs.rsna.org/doi/10.1148/radiol.2020201544                 | COVID-19 and Cardiology |
| 7    | 26     | https://pubs.rsna.org/doi/10.1148/radiol.2020201473                 | Acute Pulmonary Embolism Associated with COVID-19 Pneumonia Detected by Pulmonary CT Angiography |
| 8    | 23     | https://pubs.rsna.org/doi/10.1148/radiol.2020201160                 | COVID-19 and Cardiology |
| 9    | 22     | https://pubs.rsna.org/doi/10.1148/radiol.2020201187                 | COVID-19 and Cardiology |
| 10   | 17     | https://pubs.rsna.org/doi/10.1148/radiol.2020200642                 | COVID-19 and Cardiology |

### Table 3

Top 20 most frequently used hashtags concurrently with #Radiology

| Rank | Hashtag     | Tweets |
|------|-------------|--------|
| 1    | #COVID19    | 5,810  |
| 2    | #coronavirus| 1,098  |
| 3    | #radres     | 963    |
| 4    | #imaging    | 783    |
| 5    | #AI         | 706    |
| 6    | #Covid_19   | 551    |
| 7    | #COVID      | 482    |
| 8    | #mri        | 348    |
| 9    | #radiologia | 345    |
| 10   | #ct         | 332    |
| 11   | #MedicalImaging| 317   |
| 12   | #healthcare | 306    |
| 13   | #Cardiotwitter| 298   |
| 14   | #RT         | 289    |
| 15   | #COVID-19   | 287    |
| 16   | #medtwitter | 284    |
| 17   | #FOAMed     | 262    |
| 18   | #teleradiology| 205   |
| 19   | #ChestRad   | 195    |
| 20   | #radiologists| 193   |
tweets were retweeted from 31 to 395 times with the top 10 tweets garnering 275,978 to 1,976,155 impressions. The 10 most popular images shared are depicted in Table 4.

User Characteristics

The largest group of users was physicians comprising 48.10% (1351) of users, authoring the most tweets (4076, 40.38%), and averaging 3.02 tweets per physician. Other nonclinical healthcare individuals and nonhealthcare individuals comprised the next largest stakeholder group by number of users with 281 (10.00%) and 257 users (9.15%), respectively. Approximately 19.39% of tweets were authored by other nonclinical healthcare organizations (1957 tweets) (Table 5).

Most retweets were from physicians (2649, 51.45%) followed by researchers (558, 10.84%) and other nonhealthcare individuals (443, 8.60%). In addition, physicians made the greatest number of mentions (2322, 32.15%) followed by other nonclinical healthcare organizations (937, 12.97%) then researchers (558, 10.84%). Most impressions were generated by healthcare organizations not providing clinical care (20,235,547, 30.89%) followed by physicians (14,676,220, 22.40%) then advocacy organizations (9,499,437, 14.50%) (Table 5).
| 6 | 38 |
|---|----|
| ![Image](https://example.com) |

| 7 | 36 |
|---|----|
| ![Image](https://example.com) |

| 8 | 34 |
|---|----|
| ![Image](https://example.com) |

| 9 | 32 |
|---|----|
| ![Image](https://example.com) |

(continued)
Network Analysis

Network analysis of #Radiology COVID-19 conversation is shown in Fig 1 demonstrating the various individual and organizational stakeholders influencing the #Radiology COVID-19 conversation. The network of users primarily consists of healthcare organizations filling roles within the healthcare industry that are not providing direct clinical care (Radiopedia) and advocacy/support organizations (Aunt-Minnie, SIR, ACR) who interact with physicians directly. Users came from 80 countries spanning 6 continents. Most tweets originated from the United States (29.3%) and the United Kingdom (8.69%) (Fig 2). Within the United States, tweets came from 45 of 50 states with New York (11.2%), California (11.0%) and Massachusetts (9.59%) being the most common states tweeted from (Fig 3). Of note a percentage of users’ geolocation was unknown, globally 35.5% and nationally 4.85%.

Temporal Trends

Most tweets occurred from 8 to 11 AM (EST) on Monday through Friday with Tuesday being the most popular day. During early March, COVID-19 dominated the #Radiology conversation, making up 54.67% of tweets for the week of March 14 and 64.74% of impressions for the week of March 21 compared to the 13.97% of tweets and 16.76% of impressions in the remainder of the study period (P < 0.01) (Fig 4). There was a spike in new tweets and impressions during mid and late November corresponding to the annual RSNA conferences with no change in the number of tweets or impressions with COVID-19 content. Additionally, there was an influx of new users to the #Radiology conversation the mid-March 2 week peak with more new users tweeting about COVID-19 than not (P < 0.01) (Fig 5).

Discussion

Twitter has been a robust source of information sharing and dissemination during the COVID-19 pandemic with over 10,000 tweets containing COVID-19 content from almost 3000 unique users from February to December 2020 with the potential of almost 65 million views/impressions. With the ever-evolving pandemic, social media served as a conduit which information could be shared across the globe. Radiology departments have played an integral role in the COVID-19 pandemic, particularly for diagnosis during the early months of 2020 when rapid testing was not readily available. International and national stakeholder organizations, media organizations, various medical organizations and individuals began to use social media to share information. Physicians and other healthcare providers shared their experiences with diagnosing and dealing with COVID-19 around the world in countries to include the United Kingdom, Spain, Canada, Saudi Arabia, and the United States.

Tweets propagated during the pandemic were primarily retweets and tweets containing mentions implying content

| Shareholder type          | # Tweets (%) | Users (%) | Retweets (%) | Tweets with mentions (%) | Impressions (%) |
|---------------------------|--------------|-----------|--------------|--------------------------|-----------------|
| Doctor                    | 4076 (40.38) | 1351 (48.10) | 2649 (51.45) | 2322 (32.15) | 14,676,220 (22.40) |
| HCP                       | 416 (4.12)   | 177 (6.30) | 329 (6.39)   | 370 (5.12)    | 777,800 (1.19)   |
| Patient advocate          | 66 (0.65)    | 38 (1.35)  | 55 (1.07)    | 60 (0.83)     | 202,299 (0.31)   |
| Caregiver                 | 13 (0.13)    | 11 (0.39)  | 13 (0.25)    | 13 (0.18)     | 114,388 (0.17)   |
| Researcher/Academic       | 874 (8.66)   | 230 (8.19) | 558 (10.84)  | 770 (10.66)   | 7,847,408 (11.98) |
| Journalist/Media          | 201 (1.99)   | 39 (1.39)  | 75 (1.46)    | 122 (1.69)    | 490,948 (0.75)   |
| Individual other health   | 562 (5.57)   | 281 (10.00)| 391 (7.59)   | 473 (6.55)    | 2,536,244 (3.87) |
| Individual nonhealth      | 556 (5.51)   | 257 (9.15) | 443 (8.60)   | 506 (7.01)    | 2,758,304 (4.21) |
| Provider organization     | 371 (3.68)   | 72 (2.56)  | 96 (1.86)    | 260 (3.60)    | 3,204,899 (4.89) |
| Research/Academic organz. | 110 (1.09)   | 41 (1.46)  | 98 (1.90)    | 66 (0.91)     | 592,412 (0.90)   |
| Government organization   | 43 (0.43)    | 13 (0.46)  | 9 (0.17)     | 16 (0.22)     | 72,940 (0.11)    |
| Advocacy organization     | 912 (9.04)   | 146 (5.20) | 354 (6.88)   | 557 (7.71)    | 9,499,437 (14.50)|
| Pharmaceutical organization| 6 (0.06)    | 3 (0.11)   | 1 (0.02)     | 2 (0.03)      | 29,517 (0.05)    |
| Medical device organization| 28 (0.28)   | 8 (0.28)   | 3 (0.06)     | 7 (0.10)      | 1,088,643 (1.66) |
| Media organization        | 528 (5.23)   | 50 (1.78)  | 111 (2.16)   | 239 (3.31)    | 5,510,542 (8.41) |
| Other healthcare organization| 1,957 (19.39) | 226 (8.05) | 385 (7.48)   | 937 (12.97)   | 20,235,547 (30.89)|
| Other nonhealth organization| 88 (0.87)  | 39 (1.39)  | 27 (0.52)    | 39 (0.54)     | 2,400,186 (3.66) |
amplification rather than distribution of original content by an individual user. We show the most commonly shared and viewed content including links and images were real-time case series, summarized data about typical diagnostic findings for COVID-19, and guideline statements about how to report cases suspicious for COVID-19. This study demonstrates the influence of social media on rapid information dissemination evidenced by the influx of new users to the COVID-19 #Radiology conversation at the beginning of the pandemic in mid-March around the time when the WHO declared a global pandemic (March 14). Most users were physicians, other healthcare individuals and health-care organizations denoting these shareholder types dominated the conversation and network analysis shows they primarily interacted with each other.

A major benefit of using social media for sharing information is the instant access to the most up-to-date literature available. Many
journals, national and international radiology organizations have prioritized open-access publication of COVID-19 studies and guidelines.\textsuperscript{20-29} For the average radiologist, keeping up with the latest literature can become overwhelming. Promotion and dissemination of these publications among users and their followers allows users immediate, curated access to literature that was extremely relevant to everyday practice amid the global pandemic. When users share the studies with their followers, a virtual library is created automatically, updating under the collective tag of the #Radiology and accessible to anyone with an internet connection. Indeed, this rapid dissemination of information should be considered within its context and not serve as a substitute for peer-reviewed published literature. Although this may allow for prompt passage of information in unchartered times such as during a new pandemic, care must be exercised in the delivery, interpretation and execution of any medically relevant information across any social media platform. In no way should medical decision making be made based upon anecdotal observations shared on case examples over social media. However, in our review of the information shared during the course of the early pandemic, a large percentage of tweets included links to publications aiding in the diagnosis of COVID.

FIG 4. Tweets and impressions per week in the #Radiology conversation with and without COVID-19 content. (Color version of figure is available online.)

FIG 5. New users per week in the #Radiology conversation with and without COVID-19 content. (Color version of figure is available online.)
The analysis is limited by its primarily descriptive nature and number of tweets analyzed. It is possible the remaining #Radiology tweets not included in the sample also contained COVID-19 content without utilizing our search keywords. In addition, there are likely radiology relevant tweets about COVID-19 that do not contain the #Radiology which were excluded from the data entirely. User data is limited by what is publicly available from their Twitter profile. One final limitation is that Twitter is not available to users in China, and valuable information shared during the early pandemic may not be available to the global audience. This lack of connection could have been a potential barrier to early information sharing and communication with the stakeholders first encountering COVID-19 disease in China.

Conclusions

This analysis demonstrates that the online discussion of COVID-19 in the #Radiology conversation on Twitter increased significantly during the early weeks of the pandemic, the weeks of March 14 and March 21. Real time sharing and collaboration proved a useful tool during the ongoing global pandemic providing a means for rapid global information dissemination crucial to giving patients up to date methods in diagnosing and managing an emerging and unknown pathogen. The role of social media platforms, such as Twitter, will likely remain key in international collaboration for future pandemics.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

None.

Appendix

Table A1.

| Healthcare stakeholder | Definition | Example |
|------------------------|------------|---------|
| Doctor                 | Those believed to be licensed, MD's, DO's, PhD's who bill directly for services. Includes also residents (see note). | @hjluks, @drbeckershuette |
| HCP                    | Those believed to be healthcare professionals (ie, nurses, dietitians, respiratory therapists, nurses, pharmacists etc.). | @nursefriendly, @wholify |
| Patient                | Person whose primary use of Twitter is to express their point of view as a patient with a specific disease or condition. | @ePatientDave, @thehurtblogger |
| Caregiver/Advocate     | Person who is currently or has been a direct caregiver of a family member or other closely associated individual, and/or a person who speaks on behalf of the patient. | @ReginaHolliday, @thomsod |
| Researcher/Academic    | Person who is working in the field of health related research and/or academia. Note: A PhD that do not treat patients will fall in this category. | @dgsci, @westr |
| Journalist/Media       | Person whose profession is journalism or other news related media | @charlesornstein |
| Individual other health| Person working in the healthcare industry in nonclinical role. | @andrewspng, @Sappy81 |
| Individual nonhealth   | Person not known to be directly working in the healthcare industry. | @opmarca, @asymco |
| Org. provider          | Inpatient facilities, medical groups, labs, imaging centers, and other outpatient facilities. | @cityofhope, @MayoClinic |
| Org. research/Academic | Accredited schools of upper learning (ie, universities, colleges, etc.) and healthcare research institutions/centers | @stanfordmed, @SCCTSIEducation |
| Org. government        | Government accounts at local, and national levels. | @ONC, @NHgovndeesamed | @American_Heart, @jmir1 |
| Org. advocate/support  | An organization focused on a specific set of health issues for the purpose of support, guidance and education. | @Novartis, @pfizer |
| Org. Pharma            | All organizations in the pharmaceutical industry. | @philipshealth, @medtronic, |
| Org. MedDevice         | All organizations in the medical device industry. | @nytimes, @medcitynews, |
| Org. media             | All organizations whose primary purpose is publishing or broadcast. | |
| Org. other healthcare  | Organizations filling roles within the healthcare industry that are not providing direct clinical care. | @symlur, @dellhealth |
| Org. nonhealth         | All organizations not falling into an established category. | @evernote, @apple |
| Spam/Unknown           | Accounts reported to be associated with spam or accounts which are unclassified | @Faldaprevir |

Notes:
- When an organization is part of a larger organization, then categorize similarly as to the parent organization (ex. fellowship program part of a hospital: should be Org. Provider. News account from a medical association should be Org. Advocate/Support.)
- Journals focused on specific medical specialty, condition etc. should be Org. Advocate/Support. Other healthcare related media organizations should be Org. Other Healthcare.
- Doctors. This includes residents. Medical students should be categorized as “Individual Other Health”.
- Doctors. This includes residents. Medical students should be categorized as “Individual Other Health”.

TABLE A1 Healthcare stakeholder definitions
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