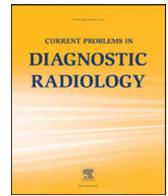




Current Problems in Diagnostic Radiology

journal homepage: www.cpdjournal.com



Artificial Intelligence and Radiology: A Social Media Perspective

Julia E. Goldberg, MD, MBA*, Andrew B. Rosenkrantz, MD, MPA

Department of Radiology, NYU Langone Health, New York, NY

ABSTRACT

Objective: To use Twitter to characterize public perspectives regarding artificial intelligence (AI) and radiology.

Methods and materials: Twitter was searched for all tweets containing the terms “artificial intelligence” and “radiology” from November 2016 to October 2017. Users posting the tweets, tweet content, and linked websites were categorized.

Results: Six hundred and five tweets were identified. These were from 407 unique users (most commonly industry-related individuals [22.6%]; radiologists only 9.3%) and linked to 216 unique websites. 42.5% of users were from the United States. The tweets mentioned machine/deep learning in 17.2%, industry in 14.0%, a medical society/conference in 13.4%, and a university in 9.8%. 6.3% mentioned a specific clinical application, most commonly oncology and lung/tuberculosis. 24.6% of tweets had a favorable stance regarding the impact of AI on radiology, 75.4% neutral, and none were unfavorable. 88.0% of linked websites leaned toward AI being positive for the field of radiology; none leaned toward AI being negative for the field. 51.9% of linked websites specifically mentioned improved efficiency for radiology with AI. 35.2% of websites described challenges for implementing AI in radiology. Of the 47.2% of websites that mentioned the issue of AI replacing radiologists, 77.5% leaned against AI replacing radiologists, 13.7% had a neutral view, and 8.8% leaned toward AI replacing radiologists.

Conclusion: These observations provide an overview of the social media discussions regarding AI in radiology. While noting challenges, the discussions were overwhelmingly positive toward the transformative impact of AI on radiology and leaned against AI replacing radiologists. Greater radiologist engagement in this online social media dialog is encouraged.

© 2018 Elsevier Inc. All rights reserved.

Introduction

Artificial intelligence (AI) in medicine employs advanced computing algorithms to identify patterns in healthcare data.¹ AI has demonstrated promising results for various radiological functions, such as identification of mammographic lesions, assessment of skeletal maturity, and detection of abnormal lymph nodes.^{2–4}

AI's expansion in radiology evokes a multifaceted discussion about its future prospects and challenges.⁵ Significant academic discussion has focused on whether AI will replace radiologists, with some stakeholders supporting the stance that radiologists will indeed be displaced.^{6,7} Meanwhile, limitations of AI in radiology have also been described, especially related to regulatory challenges, legal liability, and patient's acceptance.⁵

Much of this academic discussion has occurred in select academic journals and medical conferences,^{1,5–15} and while engaging the healthcare providers involved in such spaces, has not necessarily reached broader audiences. In comparison, Twitter provides a micro-blogging social media platform on which any individual or organization can post publicly available tweets, with 336 million monthly active users and an estimated 500 million tweets posted daily.^{16,17}

Within the academic radiology community, Twitter has increasingly been used at society meetings and for promoting academic discussions.^{18,19} On a wider scale, Twitter has been employed to assess social media discussions and public opinion on various clinical topics,^{20–23} providing insights into broader conversations among academic and nonacademic perspectives.

This study aims to use Twitter to characterize public perspectives regarding AI in radiology.

Methods

As this study did not use private health information, it did not represent human subjects research and did not require local institutional review board oversight.

Twitter was searched using the platform's native search function for the phrase “artificial intelligence radiology,” thereby returning all tweets containing all 3 of these terms. The search was conducted in November and December 2017 for tweets occurring from November 2016 through October 2017. The recorded tweets were then manually reviewed for the following characteristics:

- Category of user posting the tweet [radiologist, nonradiologist physician, industry-related individual, media/marketing-related individual, radiology practice/facility, radiology-related organization, nonradiology healthcare organization, technology/data organization, healthcare media, technology/data media, individual (other), other/unknown]; determined based on assessment

Funding: There was no funding for this project.

Disclosures: Author Rosenkrantz is supported by a research grant from the Harvey L. Neiman Health Policy Institute.

Conflict of interest: None of the authors have a conflict of interest.

* Reprint requests to: Julia E. Goldberg, MD, MBA, NYU Langone Health, 660 1st Avenue, New York, NY 10016.

E-mail address: julia.goldberg@nyulangone.org (J.E. Goldberg).

<https://doi.org/10.1067/j.cpradiol.2018.07.005>

0363-0188/© 2018 Elsevier Inc. All rights reserved.

of the user's Twitter handle, biographic description, and linked user website.

- Geographic location of user posting the tweet (United States, non-United States, unable to classify).
- Mention of specific themes within the tweet text (machine/deep learning, specific clinical application, medical society/conference, lecture, academic journal/research, university, industry, start-up/investment, AI replacing radiologists, AI transforming radiology, limitations of AI).
- Stance of the tweet regarding the impact of AI on radiology (favorable, unfavorable, neutral).
- Presence of a link to an external website. Links were excluded for the following reasons: broken link (e.g., providing an error rather than linking to an actual webpage) (n = 16), linking to a non-English webpage (n = 2), linking to identical content as previously recorded (n = 21), linking to restricted content that was not publicly available (n = 2), and linking to a webpage without content (n = 5).
- Category of link source (radiology media, healthcare media, technology/data media, mainstream media, nonmedia healthcare-related organization, technology/data organization, social media/personal blog, other/unknown).
- Mention of specific themes related to AI within the linked website (efficiency improvements, ethical issues, legal/regulatory issues, other limitations/challenges).
- Presence of content in linked websites specifically related to the topic of AI and radiology.
- Stance of linked websites regarding the issues of AI replacing radiologists and the impact of AI on radiology.

The recorded characteristics were assessed with standard summary statistics using Excel for Windows (version 16.10; Microsoft Corporation; Redmond, WA). Tweet content was stratified by time period (first vs. second 6-month period of the 1-year study window) and by category of user posting the tweet.

Results

A total of 605 tweets relating to AI and radiology were identified. These tweets were posted by 407 unique users. 42.5% of users were from locations in the United States and 35.1% from locations not in the United States; the location could not be classified for 22.4%. The posts were from a wide variety of user categories (Table 1), most commonly an industry-related individual (22.6%), individual (other) (9.6%), radiologist (9.3%), nonradiology healthcare organization (8.8%), and nonradiologist physician (7.1%).

The most commonly mentioned themes in the tweets (Table 2) were machine/deep learning (17.2%), industry (14.0%), a medical society/conference (13.4%), and a university (9.8%). The most commonly mentioned specific clinical applications (6.3%) were cancer/oncology

TABLE 1
User categories, listed in order of decreasing frequency

	Frequency (n = 407)
Industry-related individual	22.6% (92)
Individual (other)	9.6% (39)
Radiologist	9.3% (38)
Nonradiology healthcare organization	8.8% (36)
Nonradiologist physician	7.1% (29)
Media/marketing-related individual	6.9% (28)
Healthcare media	5.9% (24)
Radiology-related organization	5.7% (23)
Technology/data organization	4.9% (20)
Technology/data media	4.2% (17)
Radiology practice/facility	3.9% (16)
Other/unknown	11.1% (45)

TABLE 2
Themes mentioned in tweets, listed in order of decreasing frequency

	Frequency (n = 605)
Machine/deep learning	17.2% (104)
Industry	14.0% (85)
Medical society/conference	13.4% (81)
University	9.8% (59)
AI replacing radiologists	8.4% (51)
AI transforming radiology	7.9% (48)
Specific clinical application	6.3% (38)
Lecture	3.5% (21)
Limitations of AI	2.5% (15)
Start-up/investment	2.3% (14)
Academic journal/research	1.8% (11)

(n = 16), lung/tuberculosis (n = 13), breast/mammography (n = 6), and bone (n = 3). A total of 24.6% of tweets had the stance that AI will favorably impact the field of radiology, 75.4% were neutral regarding the impact of AI on radiology, and no tweet had the stance that AI will unfavorably impact radiology (Fig 1a). A favorable stance toward the impact of AI on radiology was observed in 19.9% of tweets in the first 6 months compared with 29.1% of tweets in the second 6 months. The themes most commonly mentioned by radiologists were a medical society/conference (25.8%) and AI replacing radiologists (19.7%).

The tweets contained a total of 216 unique links that were included for further analysis. 95.8% of these links included content relating specifically to AI in radiology. The most common link sources (Table 3) were radiology media (24.1%), healthcare media (24.1%), nonmedia healthcare-related organization (14.4%), mainstream media (13.9%), and technology/data media (10.2%).

Among these links, 51.9% mentioned AI-related efficiency/workflow improvements, 17.6% legal/regulatory issues, 4.6% ethical issues, and 29.2% other AI limitations/challenges (Table 4). Combining these mentions, 35.2% (n = 76) referenced at least one such limitation or challenge. A total of 4.2% of the linked websites leaned toward AI replacing radiologists, 36.6% leaned against AI replacing radiologists, 6.5% presented both sides in a balanced way, and 52.8% did not mention this issue (Fig 1b). A total of 88.0% of linked websites leaned toward AI being positive for the field of radiology, 3.2% presented both sides in a balanced way, and 8.8% did not address this topic; none leaned toward AI being negative toward the field of radiology (Fig 1c).

Discussion

Conversations on the role and potential of AI in radiology continue not only within the medical community, but also in the public sphere. Twitter helps reveal some of the major themes, stances, and public perspectives within these conversations. We observed that a wide spectrum of users were engaged in this online social media dialog regarding AI and radiology. The types of users that posted on this topic reveal a diversity of backgrounds of individuals and organizations. While these users predictably included many individuals and organizations with a healthcare background, there was also substantial representation from industry and media-related individuals and organizations. Further, while many users were centered in the United States, over a third were located internationally. This professional and geographic diversity of users reflects a more complete assessment of the discussions on AI in radiology than is seen solely within United States-focused academic circles.

Stances on the impact of AI on radiology reflect attitudes toward AI's documented or projected influence in the field. The tweets themselves were mostly neutral in this regard, though the linked websites were overwhelmingly positive and optimistic toward AI's impact on radiology. More specifically, the majority of included links referenced

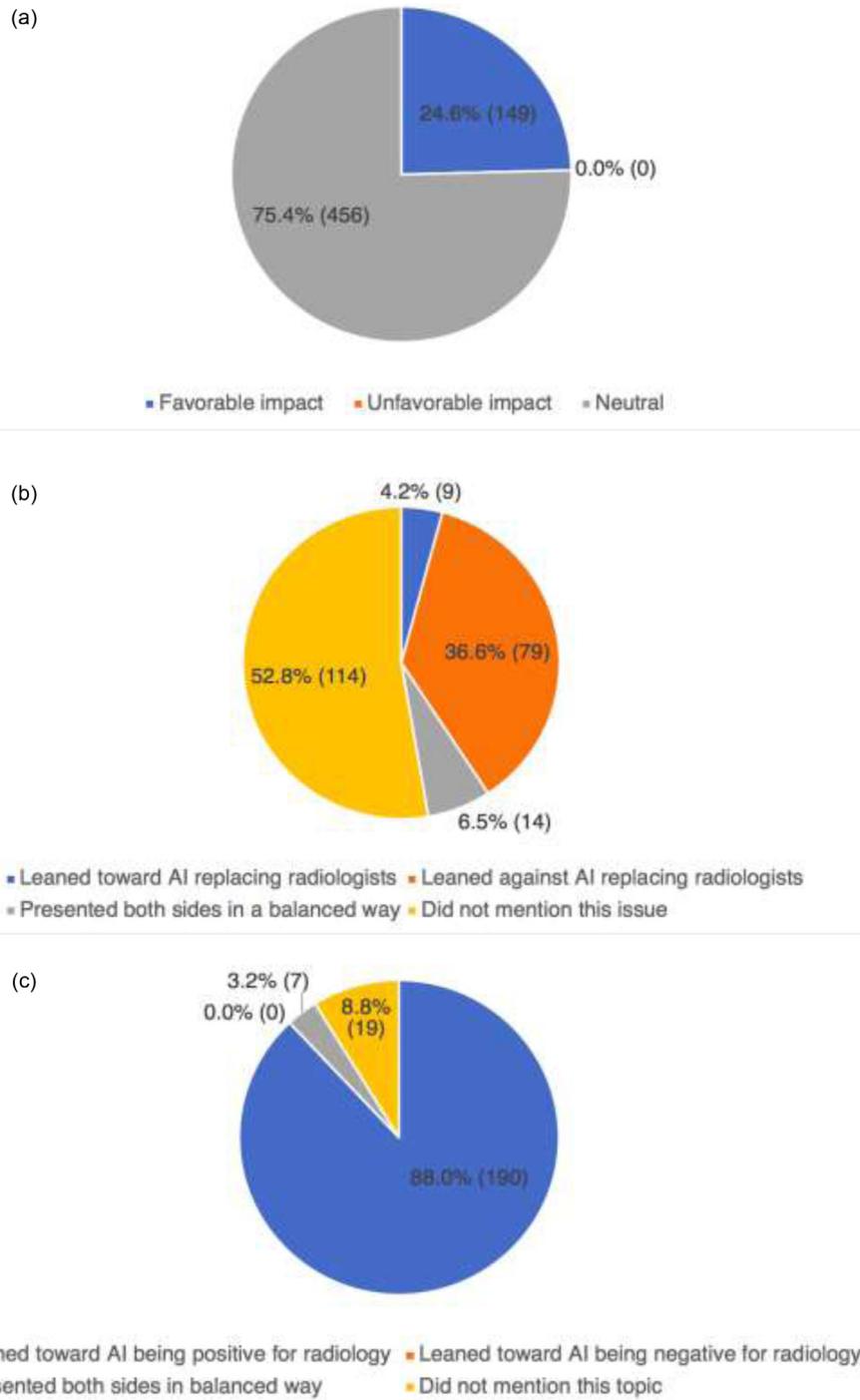


FIG 1. Stances in (a) tweets regarding impact of AI on radiology (n = 605), (b) linked websites on AI replacing radiologists (n = 216), and (c) linked websites on how AI will impact field of radiology (n = 216).

TABLE 3
Sources of linked websites, listed in order of decreasing frequency

	Frequency (n = 216)
Radiology media	24.1% (52)
Healthcare media	24.1% (52)
Nonmedia healthcare-related organization	14.4% (31)
Mainstream media	13.9% (30)
Technology/data media	10.2% (22)
Technology/data organization	4.6% (10)
Social media/personal blog	6.5% (14)
Other/unknown	2.3% (5)

efficiency/workflow improvements. Past academic discussions also identified opportunities for AI to improve efficiency and create more optimal workflows,^{11,12} while others have likened AI's potential to

TABLE 4
Themes related to AI in radiology within linked websites

	Frequency (n = 216)
Efficiency/workflow improvements	51.9% (112)
Legal/regulatory issues	17.6% (38)
Ethical issues	4.6% (10)
Other limitations/challenges	29.2% (63)

previous digital transformations in the field.¹ The conversations on the role of AI in radiology will likely change over time as AI is further developed and implemented in clinical spaces. Even within the 1-year time period of this study, the frequency of tweets that leaned toward AI having a favorable impact on radiology increased slightly from the first 6-month period to the second 6-month period, which may reflect broader shifts in public opinion on this topic.

Despite the overall favorable stance, various challenges and concerns served as recurring themes. Over a third of links mentioned at least one challenge regarding AI in radiology, most commonly legal/regulatory issues. This challenge has been recognized in the published literature as well,^{5,12} and has been noted to possibly impede AI's ability to replace radiologists.⁵

The possibility of AI replacing radiologists is a major concern to those in practice, and unsurprisingly was the second highest theme in tweets posted by radiologists. Among the links that recognized the possibility of AI replacing radiologists, the vast majority leaned against this actually occurring. Similarly, numerous articles in the peer-reviewed literature lean against AI replacing radiologists as well.^{5,9,12} The fact that a majority of links mentioned efficiency/workflow improvements, and that a majority of links discussing the issue leaned against AI replacing radiologists, reflect a commonly held view that AI will in fact benefit the field of radiology through improved efficiency but not through replacing radiologists altogether.

A notable trend throughout the user categories and tweets was a strong industry presence. There were more industry-related individuals involved in this Twitter discussion than any other user category, including all physicians combined. Moreover, industry was the second highest theme mentioned within the tweets. This presence reflects the strong industry influences that have heretofore driven much of the development of AI.^{1,7,11}

The implications of this study relate to acknowledging the variety of individuals, organizations, and perspectives involved in the discussion of AI in radiology. Twitter provides a platform through which anyone with access to the Internet can engage in such discussions, which significantly expands this conversation outside of the academic sphere. Especially considering the large industry presence in this field, radiologists are encouraged to play a substantial role in the development and implementation of AI.^{9,11} Radiologists can more fully engage with the expansion of AI though participating in these wider discussions, even if not working directly on these tools. Participating in social media discussions allows physicians to readily share their perspectives with others, including industry-related individuals who may be actively involved in developing AI applications for radiology. One study found that Twitter was identified by American radiologists as their top professional choice for a social media platform,²⁴ which further supports the use of Twitter as a straightforward tool for these purposes. Physicians are intimately aware of clinical challenges and potential opportunities for successful implementation of AI tools. On an institutional level, the American College of Radiology established the Data Science Institute in 2017 in part to engage radiologists in the process of developing and applying AI to radiology.²⁵ As radiologists continue to engage with new clinical developments, it is important for physicians to remain active within the broader AI conversations.

Limitations of this study relate to constraints common in social media research. Only tweets that included the words “artificial,” “intelligence,” and “radiology” were included. Other tweets posted on this topic that used different terminology would therefore not have been included. Further, many social media platforms besides Twitter are also used to share and discuss content. Thus, our study may not reflect the full range of this social media discussion. Additionally, during the study time period, Twitter had a 140 character limit for each tweet. The available tweet space may have limited the users' abilities to fully describe their perspectives and mention

topics deemed to be relevant to AI in radiology. Finally, only content in English was included.

In conclusion, this study reveals a generally optimistic opinion on Twitter regarding the impact of AI on radiology, especially when considering workflow improvements. While noting challenges, these social media discussions were overwhelmingly positive toward the transformative impact of AI on radiology and leaned against AI replacing radiologists. The stances and themes in the social media conversations may reflect broader awareness on this topic and shifts in public opinion that have occurred since the initial advent of AI in medicine. Radiologists are encouraged to recognize the role of these public conversations and to engage widely with such discussions regarding AI in radiology.

References

- Dreyer KJ, Geis JR. When machines think: radiology's next frontier. *Radiology* 2017;285:713–8.
- Kooi T, Litjens G, Van Ginneken B, et al. Large scale deep learning for computer aided detection of mammographic lesions. *Med Image Anal* 2017;35:303–12.
- Larson DB, Chen MC, Lungren MP, et al. Performance of a deep-learning neural network model in assessing skeletal maturity on pediatric hand radiographs. *Radiology* 2018;287:313–22.
- Liu J, Hoffman J, Zhao J, et al. Mediastinal lymph node detection and station mapping on chest CT using spatial priors and random forest. *Med Phys* 2016;43:4362.
- Recht M, Bryan RN. Artificial intelligence: threat or boon to radiologists? *J Am Coll Radiol*: JACR 2017;14:1476–80.
- Obermeyer Z, Emanuel EJ. Predicting the future—big data, machine learning, and clinical medicine. *N Engl J Med* 2016;375:1216–9.
- Chockley K, Emanuel E. The end of radiology? Three threats to the future practice of radiology. *J Am Coll Radiol*: JACR 2016;13:1415–20.
- Chartrand G, Cheng PM, Vorontsov E, et al. Deep learning: a primer for radiologists. *Radiographics* 2017;37:2113–31.
- Dreyer K, Allen B. Artificial intelligence in health care: brave new world or golden opportunity? *J Am Coll Radiol*: JACR 2018;15:655–7.
- Erickson BJ, Korfiatis P, Akkus Z, et al. Machine learning for medical imaging. *Radiographics* 2017;37:505–15.
- King BF Jr. Artificial intelligence and radiology: what will the future hold? *J Am Coll Radiol*: JACR 2018;15:501–3.
- Thrall JH, Li X, Li Q, et al. Artificial intelligence and machine learning in radiology: opportunities, challenges, pitfalls, and criteria for success. *J Am Coll Radiol*: JACR 2018;15:504–8.
- Tang A, Tam R, Cadrin-Chenevert A, et al. Canadian Association of Radiologists white paper on artificial intelligence in radiology. *Can Assoc Radiol J* 2018;69:120–35.
- Kohli MD, Summers RM, Geis JR. Medical image data and datasets in the era of machine learning—whitepaper from the 2016 C-MIMI meeting dataset session. *J Digit Imaging* 2017;30:392–9.
- Kruskal JB, Berkowitz S, Geis JR, et al. Big data and machine learning—strategies for driving this bus: a summary of the 2016 intersociety summer conference. *J Am Coll Radiol*: JACR 2017;14:811–7.
- Twitter. Q1 2018 Earnings Report 2018. Available at: http://files.shareholder.com/downloads/AMDA-2F526X/6270616715x0x978174/09E30FD3-BCD0-4DDF-9B06-B46E57A8B278/Q1_2018_Slide_Presentation.pdf. Accessed May 18, 2018.
- Twitter Usage Statistics: InternetLiveStats.com. Available at: <http://www.internet-livestats.com/twitter-statistics/>. Accessed May 18, 2018.
- Hawkins CM, Duszak R, Rawson JV. Social media in radiology: early trends in Twitter microblogging at radiology's largest international meeting. *J Am Coll Radiol*: JACR 2014;11:387–90.
- Rosenkrantz AB, Hawkins CM. Use of twitter polls to determine public opinion regarding content presented at a major national specialty society meeting. *J Am Coll Radiol*: JACR 2017;14:177–82.
- Prabhu V, Rosenkrantz AB. Imbalance of opinions expressed on Twitter relating to CT radiation risk: an opportunity for increased radiologist representation. *AJR Am J Roentgenol* 2015;204:W48–51.
- Khasnavis S, Rosenkrantz AB, Prabhu V. Using twitter to assess the public response to the United States Preventive Services Task Force guidelines on lung cancer screening with low dose chest CT. *J Digit Imaging* 2017;30:323–7.
- Hawkins JB, Brownstein JS, Tuli G, et al. Measuring patient-perceived quality of care in US hospitals using Twitter. *BMJ Qual Saf* 2016;25:404–13.
- Rosenkrantz AB, Labib A, Pysarenko K, et al. What do patients tweet about their mammography experience? *Acad Radiol* 2016;23:1367–71.
- Ranschaert ER, Van Ooijen PM, McGinty GB, et al. Radiologists' usage of social media: results of the ransom survey. *J Digit Imaging* 2016;29:443–9.
- McGinty GB, Allen B Jr. The ACR data science institute and ai advisory group: harnessing the power of artificial intelligence to improve patient care. *J Am Coll Radiol*: JACR 2018;15:577–9.