



## #radonc: Growth of the global radiation oncology Twitter network

Arpan V. Prabhu<sup>a</sup>, Sushil Beriwal<sup>b,c</sup>, Wasim Ahmed<sup>d</sup>, Varun Ayyaswami<sup>e</sup>, Richard Simcock<sup>f</sup>, Matthew S. Katz<sup>g,\*</sup><sup>a</sup> UAMS Winthrop P. Rockefeller Cancer Institute, University of Arkansas for Medical Sciences, Little Rock, AR, USA<sup>b</sup> Allegheny Health Network Academic Chief, Pittsburgh, PA, USA<sup>c</sup> Vice President of Varian Medical Systems, Palo Alto, CA, USA<sup>d</sup> Department of Marketing, Operations and Systems, Newcastle University Business School, Newcastle University, Newcastle upon Tyne, UK<sup>e</sup> University of Massachusetts Medical School, Worcester, MA, USA<sup>f</sup> Sussex Cancer Centre, Brighton and Sussex University Hospitals NHS Trust, Brighton, UK<sup>g</sup> Lowell General Hospital, Lowell, MA, USA

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## ABSTRACT

**Introduction:** Social media connects people globally and may enhance access to radiation oncology information. We characterized the global growth of the radiation oncology Twitter community using the hashtag #radonc.**Materials and Methods:** We analyzed all public tweets bearing the hashtag #radonc from 2014 to 2019 using Symplur Signals. We collected data on #radonc activity and growth, stakeholder distribution, user geolocation, and languages. We obtained global Twitter user data and calculated average annual growth rates for users and tweets. We analyzed growth rates by stakeholder. We conducted thematic analysis on a sample of tweets in each three-year period using frequently occurring two-word combinations.**Results:** We identified 193,115 tweets including #radonc composed by 16,645 Twitter users. Globally, users wrote in 35 languages and came from 122 countries, with the known highest users from the United States, United Kingdom, and Spain. Use of #radonc expanded from 23 countries in 2014 to 116 in 2019. The average annual growth rate in #radonc users and tweets was 70.5% and 69.2%, respectively. The annual growth rate of #radonc users was significantly higher than for all Twitter users ( $p = 0.004$ ). While doctors were the source of 46.9% of all tweets, research and government organizations had annual increases in tweet volume of 84.6% and 211.4%, respectively. From 2014 to 2016, promotion of the radiation oncology community was the most active theme, though this dropped to 7th in 2017–2019 as discussion increased regarding aspects of radiation and treated disease sites.**Conclusion:** Use of #radonc has grown rapidly into a global community. Focused discussion related to radiation oncology has outpaced the growth of general Twitter use, both among physicians and non-physicians. #radonc has grown into a self-sustaining community. Further research is necessary to define the risks and benefits of social media in medicine and to determine whether it adds value to oncology practice.

## Introduction

Social media connects global communities of patients, health care providers, and institutions [1–6]. Twitter ([www.twitter.com](http://www.twitter.com), Twitter Inc; San Francisco, CA) is a highly active public microblogging network with over 186 million active users communicating using micro-blogs of up to 280 characters, called “tweets” [7]. Hashtags, or a word or phrase starting with the “#” symbol can be added to tweets to allow users to search for information and to participate in discussions on particular

topics. Hashtags function as metadata tags that facilitate conversations to promote a sense of community [8].

In 2014, the hashtag #radonc was developed specifically to help organize interest in radiation oncology, in part for an online journal club [9]. The purpose of our study was to characterize global growth in the radiation oncology Twitter network #radonc stakeholders from 2014 to 2019. We hypothesized that this community has grown in the last 6 years. We sought to determine whether use of #radonc showed any indication of broadening awareness of radiation oncology

\* Corresponding author at: Department of Radiation Medicine, Lowell General Hospital, 295 Varnum Avenue, Lowell, MA 01854, USA.

E-mail addresses: [arpan.prabhu@gmail.com](mailto:arpan.prabhu@gmail.com) (A.V. Prabhu), [Sushil.Beriwal@ahn.org](mailto:Sushil.Beriwal@ahn.org) (S. Beriwal), [mail2wahmed@gmail.com](mailto:mail2wahmed@gmail.com) (W. Ahmed), [varun.ayyaswami@gmail.com](mailto:varun.ayyaswami@gmail.com) (V. Ayyaswami), [richard.simcock@nhs.net](mailto:richard.simcock@nhs.net) (R. Simcock), [Matthew.Katz@roa-ne.com](mailto:Matthew.Katz@roa-ne.com) (M.S. Katz).<https://doi.org/10.1016/j.ctro.2021.09.005>

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geographically or among non-radiation oncologists. We also sought to do a thematic content analysis for #radonc to determine the key themes of discussion occurring over the time period.

## Materials and methods

This study was deemed exempt from Institutional Review Board approval at Lowell General Hospital, Lowell, MA.

### Cohort population

We identified and analyzed all publicly-available radiation oncology-related tweets bearing the hashtag “#radonc” from January 1, 2014 00:00:00 through January 1, 2020 00:00:00 UTC (Coordinate Universal Time) for a total 6-year time period using Symplur Signals ([www.symplur.com](http://www.symplur.com), Symplur LLC; Upland, CA), a health care social media analytics platform [10].

### Endpoints and statistics

Activity was quantified by the number of tweets, users, and the number of impressions (potential tweet views) from 2014 to 2019. Impressions do not represent the total number of views or interactions, but rather the number of times a user (unique Twitter handle) was given the opportunity to view a tweet containing the #radonc hashtag on their account. We used location data to identify the most frequent countries and U.S. states in which users reside. Tweet language analysis illustrated the language used by active participants over the time period of the study using a language processing algorithm provided through the Twitter API.

User characteristics and engagement were defined through Twitter by number of retweets, replies, follows, likes, mentions, and use of hashtags [11]. To describe the overall cohort, we evaluated #radonc hashtag use in aggregate and by stakeholder groups defined by the software: patient advocates (either patients or advocates based on Twitter profile); doctors; nonphysician health care professionals (HCPs); caregivers; government organizations; academic or research organizations; advocacy organizations; media organizations; and pharmaceutical industry companies [12].

Engagement data was summarized with descriptive statistics. Linear regressions were also performed with the use of spreadsheet software (Excel 2017; Microsoft; Redmond, Washington) to understand trends in Twitter activity. The growth of the number of users and tweets with #radonc were compared to global Twitter user data obtained from statista.com, a leading provider of market data [13]. We evaluated global growth by quantifying the number of U.S. versus non-U.S. accounts and calculating the growth rate of both account types. In order to evaluate potential awareness of radiation oncology by growth in #radonc tweets was limited to physicians, we calculated five year average annual growth estimates for physicians, patient advocates, caregivers, journalists, and media organizations. Total tweets analyzed by stakeholder was larger because some users may be classified in more than one category (e.g., doctor and researcher). Two-sample T tests were used to compare the annual growth rates in our analysis, with a p-value < 0.05 used to reject the null hypothesis.

### Content and network analysis

We first examined data from 2014 to 2016 related to the community. A 20% random sample was extracted from the larger dataset; 7,861 tweets were selected out of 39,302 from 25/01/2014 to 31/12/2016. Data was then filtered from 2017 to 2019 by removing a 5% sample from the total volume of 150,185 tweets. The percentage of tweets extracted were lowered due to the large volume of tweets. There were 7,510 tweets selected from 01/01/2017 to 31/12/2019 to ensure that a similar representative number of tweets were examined across the sample.

The extracted data was then entered into NodeXL software (Social Media Research Foundation, California, CA, USA) [14], a useful tool for identifying key themes in social media discussions [15,16], which ran an automated content analysis in order to identify the 20 most frequently occurring two-word combinations (excluding hashtags) within the dataset (Appendices A and B). NodeXL draws upon a type of Natural Language Processing (NLP) that looks for co-occurring words known as topic segmentation. Previous research on Twitter has utilized similar mixed methods to gain insight into the key topics being discussed on Twitter [17,18].

These were then used to identifying overarching themes related to the discussion and uncover the most prominent themes during each three-year period.

## Results

### Activity, user characteristics, & engagement

From 2014 to 2019, we identified 193,115 tweets bearing the hashtag #radonc composed by 16,645 unique Twitter users from 122 countries using 35 written languages. The average annual growth rate of total #radonc users and tweets was 70.5% and 69.2%, respectively (Table 1). The annual growth of #radonc users was significantly higher than the annual growth rate of all Twitter users ( $t = 3.92$ ;  $p = 0.004$ ). Of the 16,645 accounts tweeting with #radonc, 13,957 (83.9%) shared 1–5 tweets with the hashtag while 899 (5.4%) had shared > 25 tweets with the hashtag (Table 2). 113 (0.7%) posted 250 or more tweets. Almost two thirds (65.2%) were re-tweets.

### Global distribution and growth

Among the 42.9% of users with identifiable locations, the United States (40.5%), United Kingdom (16.5%), Spain (8.9%), and Australia (6.1%) had the greatest number of #radonc users. Within the United States, New York (10.1%), California (9.6%), Texas (9.6%), and Ohio (5.8%) had the most participants. Alaska, New Mexico, Vermont, North Dakota, and South Dakota had the least participants (<1%). Tweets were written in 25 languages with the majority written in English (89.2%) followed by Spanish (5.4%) and French (1.5%). The proportion of users having a known location increased from 23.8% in 2014 to 61.3% in 2019.

Use of #radonc expanded to an increasing number of countries by an average of 39.8% annually, rising from 23 countries in 2014 to 116 in 2019 (Fig. 1). The growth of users with an unknown location was 53.7%, lower than that of US-based (104.0%) ( $p = 0.09$ ) or non-US (103.2%) users of #radonc ( $p = 0.08$ ).

Network analysis of the #radonc hashtag is shown in Fig. 2a and b from 2014 to 2019; these give a visual illustration of the complexity of the communication network and show that the central communication hubs were largely individuals, advocacy organizations, and provider organizations.

**Table 1**

Growth of #radonc tweets and users, 2014–2019.

Year	#radonc Tweets	#radonc Users	#radonc Impressions	Global Twitter Users
2014	5685	656	13 m	235 m
2015	13,066	1523	37 m	237 m
2016	20,770	2542	49 m	247 m
2017	31,314	3992	66 m	255 m
2018	48,886	6348	115 m	263 m
2019	73,394	8720	179 m	297 m
AAGR	69.2%	70.5%	77.1%	4.9%

\*AAGR is average annual growth rate; m = million.

**Table 2**

Breakdown of #radonc tweet volumes, 2014–2019.

Tweets	No. Users	% of Total
1–5	13,957	83.9%
6–10	998	6.0%
11–15	415	2.5%
16–20	207	1.2%
21–25	169	1.0%
>25	899	5.4%

### Stakeholder distribution and growth

When analyzed by stakeholder categories, doctors were the source of 100,790/214,904 (46.9%) tweets with an annual growth rate of 55.3% (Fig. 3 and Table 3). For the entire study period, patient advocates and caregivers together accounted for 3,179 (1.5%) tweets, while journalists/media individuals and media organizations accounted for 1.2% and 2.1% of tweets, respectively. Interestingly, only the subgroup of tweets that were unable to be tied to a particular stakeholder and labeled as unknown had a significantly greater annual tweet growth rate compared to doctors ( $p = 0.08$ ). Research and government organizations had average annual increases in tweet volume of 84.6% and 211.4%, respectively. Advocacy organizations grew similarly to doctors at 51.6% annually.

### Content analysis

Table 4 provides an overview of key themes discussed by users in this time period. There were a wide variety of discussions focused on promotion of the community as well as general discussions, discussions around specific types of cancers and radiation related discussions. Table 5 shows a comparison of themes between 2014 and 2016 and 2017–2019 by rank. The main discussions from 2014 to 2016 appeared to be wider ranging from lung cancer, prostate cancer, red journal promotion, breast cancer, head and neck cancer, and bone metastasis. The largest theme within the network from 2014 to 2016 was promotion of the radiation oncology community itself ( $n = 567$ ). Once the community had grown, there appeared to be less promotion-based tweets, and that theme dropped down to rank 7 in 2017–2019 ( $n = 71$ ). As shown in Table 5, the largest theme within the network from 2017 to 2019 consisted of discussions around various aspects of radiation ( $n = 875$ ). The main discussions also appeared to be more focused and based around other topics such as prostate cancer, lung cancer, breast cancer, and head and neck cancer as well as general discussions and promotion of the community itself.

### Discussion

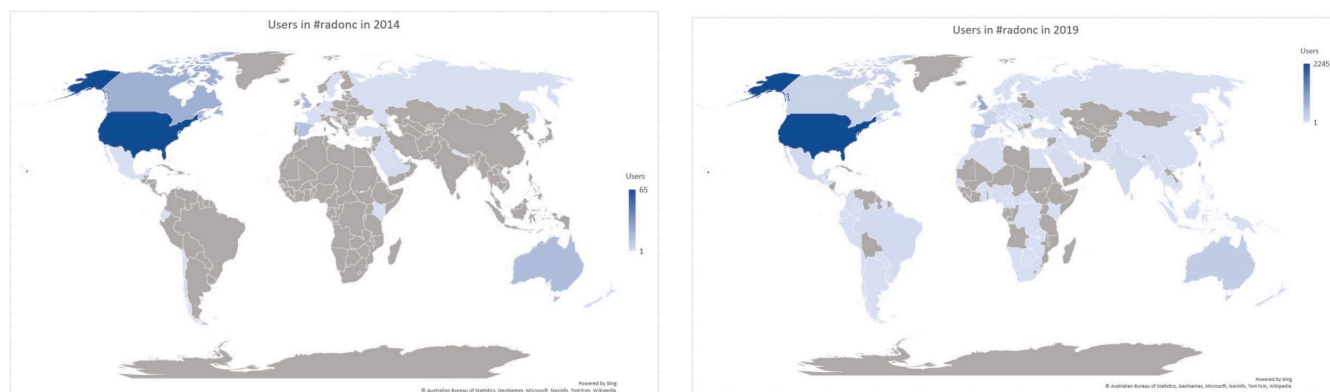
In this study, we characterized the radiation oncology global Twitter #radonc community by analyzing all public tweets from 2014 through 2019. We observed that the growth rate of #radonc content was significantly greater than the global growth rate of all Twitter activity in the same period. Radiation oncology has been a relatively late adopter of social media, likely explaining its rapid growth on the platform after its widespread use by the general public.

Another recent report identified growth of radiation oncology-related tweets by aggregating tweets using some keywords along with two hashtags, #radonc or #radiationoncology.<sup>101</sup> This analysis focused upon growth in activity but did not do a formal content analysis. Because #radonc was a community of interest by design from its inception in 2014, our study provides a more useful dataset for analyzing thematic changes over time in the #radonc community (Tables 4, 5, Appendices A, B).

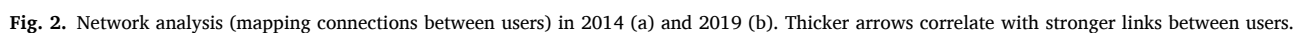
Interestingly, the most common theme from 2014 to 2016 was promotion of the community itself, which captures the early feel of #radonc around a growing community with journal club as a common activity to engage others. This theme dropped down considerably in 2017–2019, suggesting that once the community was established, there was less of a need to promote it. Overall, this observation suggests that professional-centered communities of interest can become self-sustaining with increased growth and engagement.

Whether new communities of interest add value for radiation oncologists is unknown. One potential benefit is the opportunity on social media to learn from other physicians but also from people with cancer sharing their experiences. Survey literature has shown that the vast majority of radiation oncology trainees agreed that social media exposed them to novel educational content [19]. That said, patients infrequently participate in this radiation oncology online community, similar to other areas of medicine like vascular surgery [20]. A recent report on social media use at ASCO's annual meeting suggested physician use outpaced those from patient advocates [21]. Our data suggest that use of #radonc by non-physicians is increasing, suggesting a different trend. We did not do a content analysis to determine whether increased use of #radonc by non-radiation oncologists is simply retweeting content, more people following radiation oncologists, or independently sharing radiation oncology-related content. However, we suspect that it may represent a generalized signal that radiation oncologists are effectively reaching people and organizations beyond their more traditional, non-digital sphere of influence.

If that hypothesis could be confirmed, it might indicate that social media could be an effective communication tool to enhance patient education and public understanding of radiation oncology. With the current coronavirus pandemic and the shift to more virtual platforms in medicine, the potential value of social media may increase. If people are

**Fig. 1.** Global Community of #radonc in 2014 (a) and 2019 (b).





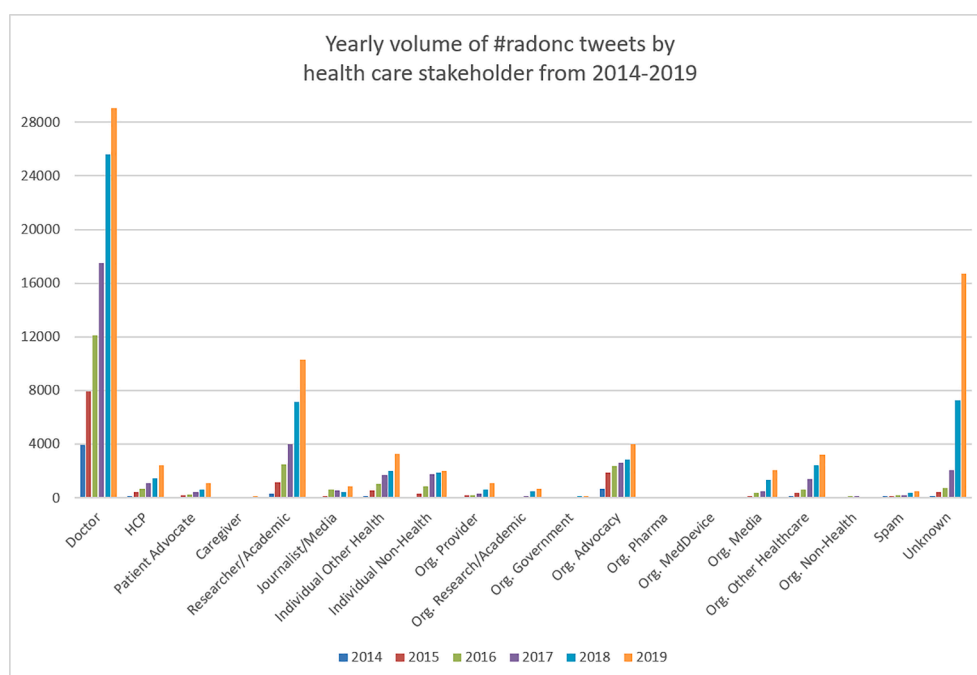


Fig. 3. Annual #radonc tweet volume by health care stakeholder, 2014–2019.

Table 3

Annual growth rate of #radonc Stakeholder Tweets.

Annual growth rate	2014–15	2015–16	2016–17	2017–18	2018–19	Average	p-value
Doctor	101.7%	52.3%	44.8%	46.3%	31.5%	55.3%	–
HCP	240.8%	67.6%	57.4%	29.2%	67.2%	92.4%	$p = 0.38$
Patient Advocate	108.3%	25.6%	57.5%	38.8%	75.3%	61.1%	$p = 0.77$
Caregiver	165.0%	–26.4%	105.1%	–23.8%	131.1%	70.2%	$p = 0.73$
Researcher/Academic	280.7%	115.6%	59.5%	78.9%	43.3%	115.6%	$p = 0.21$
Journalist/Media	4050.0%	268.7%	–12.6%	–21.9%	101.2%	877.1%	$p = 0.33$
Individual Other Health	251.2%	76.7%	64.1%	19.4%	61.8%	94.6%	$p = 0.38$
Individual Non-Health	309.7%	189.5%	109.5%	5.9%	5.5%	124.0%	$p = 0.28$
Org. Provider	266.1%	12.2%	37.4%	96.8%	80.9%	98.7%	$p = 0.37$
Org. Research/Academic	38.1%	48.3%	91.9%	220.6%	24.0%	84.6%	$p = 0.46$
Org. Government	200.0%	200.0%	566.7%	88.3%	1.8%	211.4%	$p = 0.15$
Org. Advocacy	171.6%	27.9%	10.3%	9.2%	38.8%	51.6%	$p = 0.91$
Org. Pharma	100.0%	–50.0%	100.0%	150.0%	40.0%	68.0%	$p = 0.74$
Org. MedDevice	–*	33.3%	40.0%	50.0%	–40.5%	20.7%	$p = 0.17$
Org. Media	521.7%	156.6%	37.1%	174.0%	52.2%	188.3%	$p = 0.17$
Org. Other Healthcare	174.4%	74.5%	122.8%	70.4%	34.3%	95.3%	$p = 0.18$
Org. Non-Health	60.0%	400.0%	1.7%	–19.7%	–55.1%	77.4%	$p = 0.80$
Spam	25.6%	13.2%	19.2%	83.4%	27.7%	33.8%	$p = 0.25$
Unknown	202.1%	78.3%	172.0%	248.9%	129.9%	166.3%	$p = 0.08$

\*unable to calculate growth rate due to 0 tweets in starting year.

listening, then it is critical that we understand how to share quality content meaningful to people who have an interest in cancer care.

There are limitations in our work. Our study was retrospective and conducted a content analysis to provide an overview of important themes discussed in the community over time, but a deeper thematic analysis can provide more granularity that is beyond the scope of this study. Our findings are also suggestive and not definitive due to the nature of the qualitative work with social media. Future work could conduct network and content analyses of specific stakeholders participating in the #radonc hashtag. A separate study is warranted on Spanish language use in radiation oncology Twitter communities, though it may merit examining #yosoyradiaciónólogo given its popularity in Spain.

Given increasing concerns about health misinformation shared using social media and potentially sharing patient-related information [22], we should ensure that we share well, not just share more.

## Conclusions

The use of the hashtag #radonc has grown rapidly into a global community involving 122 countries and 35 written languages. Tweets to discuss issues related to radiation oncology have outpaced the growth of general use on this social media platform. Use of #radonc by non-physicians is increasing. Based upon content analysis, #radonc has grown into a self-sustaining community of interest. We encourage further research to determine its value for radiation oncology to explore the risks and benefits of social media in medicine and to carefully monitor for harm.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

**Table 4**

Overview of themes and description of tweets.

Theme	Description
Promotion of #radonc community	Tweets in this category would promote the community such as the journal club and/or encourage users to join in on events organized by radiation oncologists.
General discussions and content	A number of general tweets were sent and received around radiation oncology, radiation oncologists and included clinic trial related discussions.
Content around radiation	There were a number of tweets focused on radiation therapy and tweets would also mention single fraction radio therapy.
Content around lung cancer including small cell lung cancer	There were a number of tweets focused on lung cancer in general as well as small cell, and non-small cancer.
Content around prostate cancer	There were a number of tweets that would mention prostate cancer within tweets
Red journal content and/or promotion	The 'red journal' refers to the International Journal of Radiation Oncology. Twitter uses would share content from this journal and/or offer general promotion towards it.
Content around breast cancer	There were a number of tweets based around breast cancer.
Content around head and neck cancer	There were a number of tweets based on head and neck cancer.
Bone metastasis	There were a number of tweets shared around the condition of bone metastasis.

**Table 5**

A comparison of themes between 2014 and 2016 and 2017–2019 by rank.

2014–2016 (Rank)	Theme	2017–2019 (Rank)
Rank 1	Promotion of #radonc community	Rank 7
Rank 3	General discussions and content	Rank 2
Rank 4	Content around radiation	Rank 1
Rank 2	Content around lung cancer including small cell lung cancer	Rank 3
Rank 5	Content around prostate cancer	Rank 5
Rank 6	Red journal content and/or promotion	N/A
Rank 8	Content around breast cancer	Rank 6
Rank 7	Content around head and neck cancer	Rank 4
Rank 9	Bone metastasis	N/A

the work reported in this paper.

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