Growth of the Digital Footprint of the Society of Critical Care Medicine Annual Congress: 2014–2020

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Objectives: Since 2014, the Society of Critical Care Medicine has encouraged "live-tweeting" through the use of specific hashtags at each annual Critical Care Congress. We describe how the digital footprint of the Society of Critical Care Medicine Congress on Twitter has evolved at a time when social media use at conferences is becoming increasingly popular.

Design: We used Symplur Signals (Symplur LLC, Pasadena, CA) to track all tweets containing the Society of Critical Care Medicine Congress hashtag for each annual meeting between 2014 and 2020. We collected data on the number of tweets, tweet characteristics, and impressions (i.e., potential views) for each year and data on the characteristics of the top 100 most actively tweeting users of that Congress.

Setting: Twitter.

Subjects: Users tweeting with the Critical Care Congress hashtag.

Interventions: Not applicable.

Measurements and Main Results: The Critical Care Congress digital footprint grew substantially from 2014 to 2020. The 2014 Critical Care Congress included 1,629 tweets by 266 users, compared with 29,657 tweets by 3,551 participants in 2020; average hourly tweets increased from 9.7 to 177. The percentage of tweets with mentions of other users and tweets with visual media increased. Users attending the conference were significantly more likely to compose original tweets, whereas those tweeting from afar were more likely to retweet Critical Care Congress content. There was a yearly increase in content-specific hashtags used in conjunction with Critical Care Congress hashtags ($n = 429$ in 2014 to $n = 22,272$ in 2020), most commonly related to pediatrics (18% of all hashtags), mobility/rehab (9%), sepsis (7%) social media (6%), and ICU burnout (1%).

Conclusions: There has been significant growth in live-tweeting at the Critical Care Congress, along with the increased use of content-specific hashtags and visual media. This digital footprint is largely driven by a proportion of highly engaged users. As medical conferences transition to completely or partially online platforms, understanding of the digital footprint is crucial for success.

Key Words: conference social media; digital health; healthcare communication; patient-centered care; social media

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Using social media to share lectures and other content presented at academic conferences, known as "live-tweeting the meeting," has become increasingly popular (1–3). Organizations create hashtags to aggregate conversations and healthcare stakeholders can join these online conversations via Twitter by tweeting with these hashtags, whether or not they are present at the conference (1–4). Live-tweeting at conferences has grown significantly from a few volunteers spontaneously tweeting and surreptitiously taking pictures of slides at lectures they were attending into

a wide array of clinicians, medical societies, industry, and patients engaging in the online conversation. Some societies organize coordinated efforts to promote live-tweeting through social media committees dedicated to increasing conference engagement (2).

Growth in social media engagement at conferences has created an opportunity to engage a large audience of stakeholders across the digital sphere, unencumbered by the limitations of geography, time, hierarchy, and work settings (5–11). The variety of disciplines represented in these discussions also ensures diversity in perspectives on any given topic (8). However, the impact of this rapid dissemination on medicine and communication between healthcare stakeholders in critical care medicine is an area that needs further exploration (12). Additionally, assessing the type of content and specific topics related to care in the ICU, which are shared on social media, can provide conference organizers with useful feedback for planning future educational offerings (2). As more conferences transition to completely or partially online platforms, the impact of social media during meetings has the potential to expand significantly in size and scope. Thus, societies and conferences that have already incorporated a culture of social media engagement may further benefit from previous establishment of a digital footprint.

Since 2014, the Society of Critical Care Medicine (SCCM) has encouraged tweeting at the annual Critical Care Congress (CCC) by using hashtags identifying the conference number (i.e., #CCC49). We sought to examine the digital footprint of the Congress and to describe how these digital footprints and the stakeholders involved in the conversations have changed over time. To take a closer look at the users involved and changing over time, we also examined the top 100 influencers tweeting the conference hashtag for each year.

MATERIALS AND METHODS

We used Symplur Signals (Symplur LLC, Pasadena, CA), an online analytic tool, to track all tweets containing the SCCM Congress hashtag for each annual meeting between 2014 and 2020 (#CCC43, #CCC44, #CCC45, #CCC46, #CCC47, #CCC48, and #CCC49) for the 7-day period around the conference. For uniformity, we chose to include Saturday to Wednesday of each Congress to include pre-Congress sessions except 2014, when the Congress was rescheduled and dates did not match traditional Saturday to Wednesday dates. One extra day was added to the analysis on either end of the Congress to collect data on pre- and post-Congress discussions. Therefore, each period includes 1 week of data (from Friday to Thursday) (**Supplemental Digital Content 1**, http://links.lww.com/CCX/A411).

We collected data on the number of tweets, users, and impressions (i.e., potential views) for each year's Congress hashtag. Tweet characteristics were collected and included the number of tweets with mentions of other users, number of tweets that included visual media (pictures, GIFs, or video), number of tweets that included links, number of tweets with replies, and number of tweets that are retweets. User characteristics such as stakeholder type, average, and median number of tweets per participant and number of users with 1 or greater than 10 tweets were also collected. Data were also collected on the words, phrases, and hashtags commonly used

with that year's CCC hashtag. Network analyses were performed using Symplur Signals that illustrate the spectrum of individual and organizational stakeholders that influenced SCCM Congress conversation. In a network analysis, the size and density of a node proportionally reflect the average amount of time a participant/user spends in conversation, and the arrows reflect the conversational connections between the nodes.

Next, we identified the top 100 influencers tweeting the conference hashtag for each year from 2014 to 2020. Top influencers were defined by the users with the largest number of tweets for that meeting using the conference hashtag. The number of tweets included original tweets and retweets. Characteristics of these users were compared including type of stakeholder (individual, individual nonhealth, healthcare providers, physicians, healthcare organizations, nonhealthcare organizations, and industry), number of tweets, number of followers, and characteristics of these users' tweets. Stakeholder types were classified by Symplur Signals, which uses a process that includes algorithms, machine learning models, and manual human evaluation to categorize 19 different categories of stakeholders (13). We aggregated the Symplur-defined categories into four groups of stakeholder types (clinicians, patients, healthcare organizations, and industry). For individuals, attendance records were obtained from the SCCM.

Descriptive and comparative statistics were performed. Data were analyzed using the JMP statistical software (Version 10.0.1; SAS Institute, Cary, NC) in collaboration with consultation from the Office of Research at the Connecticut Children's. Data are reported as frequencies (%), as mean ± sd, or as median with 25–75% interquartile range (IQR) depending on the type and distribution of the variables. A Shapiro-Wilk test was used to assess normality. Stakeholder groups were compared using appropriate parametric tests and nonparametric statistics, including chi-square, t tests, and Wilcoxon rank sum. A p value of less than 0.05 was considered statistically significant. This study was reviewed by the Connecticut Children's Institutional Review Board and considered exempt.

RESULTS

Changes in the Digital Footprint of the Critical Care Congress

The digital footprint of CCC grew from 2014 to 2020, with 1,629 tweets by 266 users resulting in 147,396 impressions in 2014, compared with 29,657 tweets by 3,551 participants and 117.6 million impressions in 2020 (**Table 1**; and **Supplemental Digital Content 2**, http://links.lww.com/CCX/A412). The average hourly tweets increased from 9.7 tweets/hr in 2014 to 177 tweets/hr in 2020, whereas the average number of tweets per participant remained relatively constant, ranging from 6.1 to 8.8 tweets (Table 1). There was tremendous growth in international engagement, with only North America represented 2014–2017; by 2019, all seven continents were represented with increased users across the globe (**Fig. 1**).

There was an increase between 2014 and 2020 in the percentage of tweets with mentions (50–85%), tweets with visual media (1–62%), and retweets (50–68%). Data on retweets are unavailable for 2014. The percentage of tweets with links appeared to be decreasing 2014–2020

TABLE 1. Digital Footprints of the Critical Care Congress by Year

Variable	2014	2015	2016	2017	2018	2019	2020
Tweets	1,629	4,293	13,846	14,169	19,821	25,678	29,657
Percent tweets with mentions (%)	50	65	70	73	86	86	85
Percent retweets (%)	—	50	60	60	72	71	68
Percent tweets with media (%)	1	32	47	42	55	59	62
Percent tweets with links (%)	35	16	13	15	13	14	8
Percent tweets with replies (%)	0	6	3	4	4	5	7
Tweets/hr	9.7	25.5	82.4	84.3	118.0	153.0	176.5
Users	266	696	1,571	2,229	2,580	3,221	3,551
Tweets per participant (mean ± SD)	6.1 ± 21.6	7.1 ± 31.1	8.8 ± 51.9	6.4 ± 39.4	7.7 ± 60.3	8.0 ± 60.4	8.4 ± 58.3
Tweets per participant (median with 25–75% interquartile range)	1 (1–3)	1 (1, 2)	1 (1–3)	1 (1, 2)	1 (1–3)	1 (1–3)	1 (1–3)
Percent users with one tweet	60% (n = 159)	54% (n = 377)	62% (n = 972)	66% (n = 1,460)	60% (n = 1,556)	59% (n = 1,887)	58% (n = 2,077)
Percent users with > 10 tweets	8% (n = 18)	8% (n = 46)	8% (n = 125)	7% (n = 149)	8% (n = 212)	8% (n = 256)	10% (n = 340)
Stakeholder type							
Clinician (%)	62	66	61	60	55	49	52
Individual nonhealth (%)	8	9	8	10	8	5	3
Healthcare organization (%)	12	11	10	11	11	10	8
Industry (%)	0	0.2	0.3	0.3	0.4	0.2	0.1
Impressions (millions)	0.1	6.2	18.5	29.1	76.1	79.9	117.6

(range 35–8%), in the context of significantly increased denominator, whereas the percentage of tweets was relatively consistent (range 0–7%) (Table 1; and **Supplemental Digital Content 3**, http://links.lww.com/CCX/A413). The percentage of users with more than 10

tweets ranged from 6.7 to 9.5%, and the number of participants sending only one tweet ranged from 54 to 66% for all years (Table 1).

More content-specific hashtags were used each year alongside the CCC hashtags (from 429 uses of other hashtags in 2014 to

Figure 1. Geographic distribution of participants tweeting with the Congress hashtag per year.

22,272 uses in 2020), most commonly related to pediatrics (18% of all hashtags), mobility/rehab (9%), sepsis (7%), social media (6%), and burnout (1%) (**Fig. 2**). A network analysis by year shows increased numbers of connections between the users of a variety of different stakeholder types (**Fig. 3**).

Characteristics of the Top 100 Influencers at the Critical Care Congress

Most of the top CCC influencers on Twitter were individuals (81%); 77% were healthcare providers (51% physicians and 26% pharmacists, nurses, physical therapists, and dietitians), 15% were organizations, and 2% were industry. Together, these top influencers were responsible for 64–84% of all conference tweets each year (**Table 2**). Individuals in this group were responsible for a median of 64% of the conference tweets/yr (25–75% IQR 53–69%).

There was a significant increase in the median number of tweets per conference by these influencers with 9 (IQR, 6–23) tweets/conference in 2015 compared with 81 (IQR, 54–137) in 2020 ($p < 0.0001$). The percentage of total conference tweets by these top influencers ranged from 28% in 2014 to a high of 84% in 2015 (median 69%; 25–75% IQR 64–78%) (Table 2).

In 2014, only 29% of these top influencers attended that year's CCC, but there was a steady increase in the percent of individuals in the top influencers who attended the CCC ($p < 0.0001$) and by 2020, 68% were Congress attendees. Users attending the conference were significantly more likely to compose original tweets (42–62%), compared with those who did not attend the conference and whose tweets were primarily retweeting what others had composed (81–100%) ($p < 0.01$ for each year other than 2014 where retweet data not available).

There were 18 user accounts who were in the cohort of top influencers for at least 5 of the 7 years: 11 of these were physicians, four were other healthcare providers (one nurse, two pharmacists, and one dietitian), and three were organizations. There were four user accounts who were top influencers all 7 years: three were physicians (Table 2) and one was the SCCM (aka @SCCM). The most prolific users had greater than 3,700 cumulative tweets.

DISCUSSION

There has been significant growth in live-tweeting at the SCCM CCC, along with increased use of content-specific hashtags, mentions, and visual media. This digital footprint is largely driven by a proportion of highly engaged users, most of whom are healthcare providers. Over the last 6 years, more of these top influencers are in attendance at the Congress, and the tweets have become more structured, perhaps reflecting a better understanding of how to use effectively Twitter for knowledge dissemination by the core influencers. Most importantly, the number of engaged critical care stakeholders on Twitter during Congress has progressively increased, with over 10 times the number of unique users in 2020 compared with 2014.

Although some healthcare societies have shunned social media and have attempted to block pictures or live-tweeting at sessions, other medical societies have embraced social media as a tool for marketing and engagement (2). Healthcare societies recognize the importance of keeping in-person attendees active on social media and are actively trying to integrate social media into presentations while also disseminating and amplifying content via social platforms. These strategies help engage those unable to attend the conference and allow for active discussion and thoughtful questions to be posed in real time (14). As the coronavirus (COVID-19) pandemic has taken center stage in 2020 with an uncertain future, the role of social media in medicine has been in the spotlight, not only for rapid information dissemination but as a method of combating misinformation (15–17). As conferences move online, the in-person interaction that is such a valuable component of conferences will vanish. However, there is potential for increased international attendance and engagement without barriers of distance and travel. Social media may play a critically important role in networking between international and interprofessional stakeholders leading up to, during, and after the event.

Using social media to disseminate information during the SCCM CCC began organically, with conversations on Twitter between friends and like-minded colleagues in 2013. The first

Figure 2. Hashtags associated with the Congress hashtag. Size of the term reflects the relative frequency of use of that hashtag for that year.

Figure 3. Network analysis by year. Network analysis of users tweeting with the Congress hashtag. The size and density of a node proportionally reflect the average amount of time a participant/user spends in conversation, and the *arrows* reflect the conversational connections between the nodes.

sessions at the CCC on the use of social media was held in 2014. In 2015, a small group of active Twitter users approached SCCM about launching a Social Media Task Force, which became the Social Media Committee in 2016. Since 2016, moderators were assigned to live-tweet specific sessions at the Congress, and hashtags were promoted by SCCM leadership in announcements and on slides. The SCCM Social Media Ambassador program was started in 2018. Examining the network analysis by year shows that Twitter use at the Congress grew into an increasingly coordinated effort, with many new participants joining in and driving the conversations (Fig. 3). Individuals involved in these initiatives and SCCM's Social Media Committee have continued to be among the most highly engaged users when tweeting at the CCC and have a significant impact on the digital footprint when examining network analyses (Fig. 3). This systemic approach to increasing engagement may be a useful strategy for an organization to grow an online community.

Healthcare providers were the most engaged participants in live-tweeting at the CCC. Additionally, those healthcare providers in attendance were more likely to postoriginal content. It is not clear if the increased percentage of influencers present at the CCC was due to increased awareness and/or popularity of live-tweeting or increased interest in attending the conference due to tweeting. However, media has long understood that the concept of "live-tweeting" encourages people to watch TV shows live to join in the conversation with a "dual screen" experience (18). The "fear of missing out" can be a powerful motivator for participation and may be driving engagement and interest in the Congress, with even higher engagement potential with the transition to an online platform for #CCC50 in 2021.

Assessing reach on social media platforms is challenging. Measuring impressions that are potential views of a tweet or hashtag based on the followers of the user tweeting is easy and frequently used. However, impressions overestimate reach, and assessing how often other users view the specific content is difficult. Engagement is also difficult to assess, and surrogate markers such as likes and replies may not fully capture engagement. Ideally, tracking the impact of a tweet—such as by downloads of specific resources mentioned (i.e., live feed session, linked journal article)—could provide helpful information for the conference planners. However, our study demonstrated a substantial increase in the number of users actually sharing Congress content using hashtags, which is a reflection of active engagement and information dissemination. For many individuals, a meeting is the first time they open a twitter account and consider utilizing the platform for professional reasons. These users are likely to continue to engage in critical care conversation on Twitter after the meeting (3, 17). Therefore, introducing new users to the critical care community on Twitter has the potential to increase social media engagement and information

TABLE 2. Characteristics of the Top 100 Influencers of the Critical Care Congress

Variable	2014	2015	2016	2017	2018	2019	2020
Overall metrics							
Total number of tweets at conference	1,629	4,293	13,846	14,169	19,821	25,678	29,657
Total number of tweets by top 100 influencers	456	3,614	10,839	9,752	13,761	17,329	18,907
Percent conference tweets by top 100 influencers	28	84	78	69	69	67	64
Number of tweets of top influencers per conference, median (IQR)	4 (2–8)	9 (6–23)	33 (21–83)	39 (23–87)	50 (31–102)	66 (41–137)	81 (54–137)
Characteristics of users							
Percent individuals	77	80	87	79	85	81	82
Percent individuals attended conference	29 (n = 22/77)	31 (n = 25/80)	45 (n = 39/87)	51 (n = 40/79)	60 (n = 51/85)	69 (n = 56/81)	68 (n = 56/82)
Percent individuals male	46 (n = 46/74)	68 (n = 53/78)	64 (n = 54/85)	52 (n = 41/79)	56 (n = 47/84)	62 (n = 50/81)	54 (n = 45/82)
Percent individuals nonhealth	12	12	1	0	1	2	7
Percent healthcare providers	65	68	86	79	84	79	77
Percent doctors	49	42	49	51	59	56	52
Percent healthcare organizations	17	15	11	15	14	18	15
Percent organization nonhealth	1	3	1	2	1	0	0
Percent industry	5	2	1	4	0	1	0
Characteristics of tweets							
Percent retweets	—	72 (30–100%)	54 (29–98%)	55 (26–98%)	69 (37–90%)	62 (28–88%)	67 (39–90%)
Percent retweets by individuals attending conference	—	38 (25–56%)	38 (21–58%)	40 (26–63%)	58 (24–75%)	41 (25–64%)	57 (34–74%)
Percent retweets by individuals not attending conference	—	100 (60–100%)	94 (38–100%)	81 (32–100%)	80 (48–100%)	90 (64–100%)	92 (62–99%)
Number of tweets of individuals attending conference, median (IQR)	7 (4–52)	10 (7–43)	45 (26–192)	42 (27–92)	57 (34–168)	59 (39–212)	92 (58–162)
Number of tweets of individuals not attending conference, median (IQR)	3 (2–7)	8 (5–18)	25 (19–65)	38 (24–68)	47 (28–88)	75 (45–122)	66 (45–128)

Retweet data not available for 2014.

dissemination beyond the meeting, expanding the size and scope of the community including interprofessional stakeholders. Another potential benefit for the users is to use the platform as documentation and reflection of the presentations and discussions while disseminating information. However, this method of engagement in continuous professional development is far from universally accepted.

Each year there has been an increase in the number of users with one tweet and in users with greater than 10 tweets. Some have questioned whether we have reached "peak tweeting" at healthcare conferences and that a minority of conference attendees are driving growth (19, 20). Our data suggest otherwise. Between 2014 and 2020, the number of participants tweeting once grew 13-fold (from 159 to 2,077) and the number tweeting greater than 10 times grew 19-fold (from 18 to 240). This suggests that users have become more engaged in recent years. Increasing numbers of users are drawn into the conversation by a group of core leaders who tweet most of the conference tweets. Our finding that the same prolific users were engaged in all years highlights that organizational investment may help to secure the attention of highly engaged users. On the other hand, it also describes the difficulties any organization faces when attracting new users of Social Media:

in general, users will be more likely engaged if they are active outside of the short period of Congress.

We also found significant changes in the hashtags tweeted alongside the CCC hashtag over time. These hashtags reflect a variety of clinical topics from specific sessions at the CCC including sepsis, ICU rehabilitation, nutrition, and PICU, among others. The hashtags may also reflect content disseminated by top users and their personal interests or clinical area of practice. In 2016–2017, SCCM promoted session-specific hashtags to separate and elevate conversations for specific sessions at the conference (2). In 2016, four of the top 10 hashtags used in conjunction with the conference hashtag were promoted session-specific hashtags, whereas in 2017, only one of the top 10 associated hashtags was session-specific hashtag.

Pediatrics has a disproportionately high and expanding role in the digital footprint of the CCC. Pediatric providers make up only about 10% of SCCM's membership, but since its creation in 2016 (20), the #PedsICU hashtag has continued to grow in use with the CCC hashtag and, in 2019, dwarfs the usage of other hashtags (Fig. 2). There are several potential reasons for strong #PedsICU participation. Pediatric providers were one of the first groups to organize on Twitter in 2012 (21) and anecdotally seem to be some of the most active and prolific Twitter users (four of the five chairs of SCCM's Social Media Committee have been pediatric providers). Additionally, in 2017, *Pediatric Critical Care Medicine* was the first SCCM Journal to appoint a Social Media Editor and Social Media Ambassador Program. Similar to the specialty's #COVID19-specific engagement, pediatrics is a significant component of the digital footprint of the CCC and of critical care on Twitter (17).

Our study is limited by several factors. The growth and importance of social media in medicine is a highly polarizing topic. Although we have shown an increase in social media use at SCCM's CCC, linking social media metrics to nondigital outcomes is challenging and is a limitation of our study. Additionally, there has been growth in medical social media use in general and in medicine over the last several years. We cannot say for certain whether the growth seen at SCCM's Congress is unique or part of that trend. Finally, some have pointed out that focusing on social media use is potentially distracting to conference attendees who might miss important speaking points while focuses on tweeting. However, others have suggested that live-tweeting helps the participant take a more active role in listening, which might further improve retention of information.

CONCLUSIONS

There has been significant growth in live-tweeting at the SCCM CCC, along with increased use of content-specific hashtags, mentions, and visual media. This digital footprint is largely driven by a proportion of highly engaged users. It is unclear whether these users will serve as a foundation for further digital growth, but as conferences transition to online formats, these users will be important to engage. Additional research on the "science of social media" and tweeting would provide important information on how conference attendees select content to tweet. Ultimately, as

social media technology further evolves, identifying the impact of live-tweeting at conferences on clinical care practices as well as integration of late breaking research findings would further elucidate digital reach.

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