

1 **How scientists and physicians use Twitter during a medical congress**

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30 **Abstract**

31 **Objectives:** During medical congresses Twitter allows discussions to disseminate beyond the
32 congress hall and reach a wider audience. Insights into the dynamics of social media
33 interactions during congresses, dissemination of scientific information and the determinants of
34 a successful tweet may allow us to better understand social media's role in science
35 communication.

36

37 **Methods:** We retrospectively extracted social media data during the European Congress of
38 Clinical Microbiology and Infectious Diseases (ECCMID) 2017 and 2018 using NodeXL. We
39 compared social media activity during these two congresses. Subsequently, we conducted in-
40 depth analyses to identify the components of a successful tweet and multivariable analysis to
41 assess independent factors associated with retweet activity.

42

43 **Results:** In 2018, approximately 13,000 delegates attended ECCMID, but only 591 Twitter
44 accounts actively tweeted about the congress. Although fewer tweets were posted in 2018
45 compared to 2017 (4,213 vs 4,657, respectively), ECCMID2018 generated a 63% increase in
46 the total number of retweets ($p < 0.001$). According to multivariable logistic regression analysis,
47 using multimedia, URL or hashtags and mentioning other Twitter account(s) were
48 independently associated with retweet success. Mentioning of other users and use of
49 multimedia were the only consistent predictors of retweets irrespective of the number of
50 followers.

51

52 **Conclusions:** A substantial increase in retweet activity and a modest increase in the number of
53 influential Twitter accounts were observed between two successive congresses. Dissemination

54 of scientific messages is more successful when connected accounts are actively involved in
55 social media activity, and social media posts constitute the right combination of components.

56

57 **Introduction:**

58 Twitter is a microblogging platform used as a communication tool by scientists as a means to
59 exchange scientific information and ideas, network with peers and initiate direct engagement
60 with non-scientific audiences [1-3]. Use of Twitter during congresses has also gained
61 momentum in helping important scientific discussions to go out of the congress hall and reach
62 a wider audience [4]. Unlike conventional media, social media facilitates two-way interaction
63 combining the roles of broadcaster and audience [5]. It also provides timely dissemination of
64 knowledge and expert opinion with the virtual participants. Tweets can be shared (retweeted)
65 and may include media (images and/or video), keywords which can be indexed and searched
66 by the social media network (hashtags), mentions of other users, and links to other information
67 on the web. These components can have an impact on the amplification of a tweet, which varies
68 depending on multiple factors [6, 7].

69

70 The European Congress of Clinical Microbiology and Infectious Diseases (ECCMID) is the
71 largest international congress in the field, organised by the European Society of Clinical
72 Microbiology and Infectious Diseases (ESCMID) which has over 7,000 individual and 30,000
73 affiliated members. ECCMID is a 5-day congress attracting nearly 13,000 scientists, physicians
74 and other healthcare staff from all around the world [8]. Many of the topics discussed at this
75 congress (e.g. antimicrobial resistance, emerging infections and vaccines) are of potential
76 interest to other professionals who cannot attend the congress in person and the general public.

77

78 This study was performed: (1) to provide a descriptive overview of the social media activity
79 during the 27th ECCMID 2017 and 28th ECCMID 2018 congresses; (2) to provide comparison
80 between two successive congresses; (3) to identify the components of tweets associated with
81 an increased probability of dissemination (retweeting).

82

83 **Methods:**

84 *Study design and data extraction*

85 We retrospectively extracted social media data (tweets, retweets, mentions) covering the
86 congress days; 22-25 April 2017 for ECCMID2017 and 21-24 April 2018 for ECCMID2018
87 utilising NodeXL, which is an Excel add-on developed by SMRF [9]. The NodeXL extract was
88 analysed to establish the number of Twitter accounts using the congress hashtag for the given
89 year (#ECCMID2017 or #ECCMID2018). We identified original tweets using Tweet ID (a
90 unique 19-digit identifier generated for each tweet) and retweets using the unique 19-digit
91 Retweet ID [10], extracting username (Twitter handle) and mentions of other Twitter accounts
92 from these tweets.

93

94 The NodeXL extracts were repeated and refined until data were available for the entire
95 congress period, thereafter, duplicate tweets and commercial tweeters were excluded.
96 Subsequently, for completeness, the number of tweets extracted by NodeXL was compared
97 with the number of tweets identified via Twitter search on Google Chrome browser. NodeXL
98 successfully captured 97.5% of tweets from the congress period. In total 282 "quoted tweets"
99 and 259 replies from ECCMID2018 data were excluded prior to univariable and multivariable
100 analysis, leaving 3,653 tweets. Components of tweets were identified by NodeXL. Hashtags
101 were identified using the preceding "#" symbol, and Twitter handles using the leading "@"
102 symbol. For the multivariable analysis tweets mentioning other tweets were identified using

103 Twitter.com domain and replies were identified as tweets beginning with the "@" symbol. Data
104 extracted from Twitter is publicly available and is therefore exempt from IRB panel review.
105 We have obtained opt-out consent from the Twitter users included in the sub-group analysis.

106

107 *Data analysis*

108 First, social media activity of ECCMID 2017 and ECCMID 2018 was compared using χ^2 test
109 and descriptive statistics. NodeXL extracts were mapped according to the estimates of
110 connectedness using information from the Twitter Application Programming Interface (API),
111 and outputs were combined into a single network map. NodeXL uses estimates of
112 connectedness, ranking users by "betweenness centrality" which measures the number of
113 "shortest paths" that pass through each Twitter user using network theory [11]. Subsequently,
114 we classified users to identify key influencers using Venn diagrams.

115

116 We used the number of retweets as an outcome measure of the reach and influence of a tweet.
117 We excluded replies to tweets and tweets that quoted another tweet and replies, because replies
118 are only seen by the user replied to and mutual followers, unless searched for specifically, and
119 the quoted tweet is typically displayed rather than any images in the tweet. In univariable
120 analysis, we assessed possible predictors of retweets. Based on previous studies [6,7], variables
121 of interest were: inclusion of multimedia (images and/or video), a link to other information on
122 the web (Uniform Resource Locator (URL)), mention of other tweeter(s), the number of
123 followers of a Twitter user and use of hashtags other than the congress hashtag. We then
124 performed multivariable logistic regression analysis using ECCMID2018 data to identify
125 independent predictors of retweet activity. We restricted this particular analysis to a single year
126 to reduce bias as Twitter introduced new rules over time; the way the tweets are displayed, and
127 the length of tweets changed in 2018. We tested for multicollinearity and interactions among

128 the included variables. Finally, we performed a subgroup analysis among the top Tweeters
129 based on the number of retweets received. We performed a descriptive analysis of the number
130 of followers, number of tweets and retweets received among these influencer users.

131

132 To ensure accurateness of the extract, the top 10 tweeters identified by betweenness centrality
133 in the NodeXL report were compared with the top 5 Twitter accounts identified in each of the
134 seven sections of the Venn diagram for tweeter, retweeter and mentioned users. Subsequently,
135 the most popular tweets were selected for further analysis and collected into congress
136 summaries listing individual tweets chronologically [11, 12]. The distribution of the tweeters
137 included in the Congress summaries was also matched the Venn diagram output.

138

139 **Results:**

140 Table 1 displays the number of Twitter accounts involved, and tweets and retweets generated
141 both in 2017 and 2018 Congress social media activity. Although the number of accounts
142 engaged in active tweeting remained relatively static (590 vs 591) and fewer tweets were posted
143 (4,213 vs 4,657) in 2018 compared to 2017, ECCMID2018 generated a 63% increase in retweet
144 activity (total number of retweets). Besides, the proportion of accounts engaged in retweeting
145 has increased ($p < 0.001$), with “just retweeters” making up the single largest group for both
146 years. The median number of followers for active tweeters also increased from 203 (IQR 47-
147 891) in 2017 to 278 (IQR 91-1,030) in 2018 ($p < 0.001$). The number of tweeters who received
148 80% of retweets was similar in both years (67 in 2017 vs 72 in 2018), while 222 (38%) active
149 tweeters received zero retweets in 2017 vs 186 (31%) in 2018 ($p < 0.001$).

150

151 *Mapping Twitter activity*

152 Figure 1 illustrates the extent of connections and dissemination of tweets [14]. Each picture
153 represents a Twitter user who either tweeted, were mentioned, and/or retweeted posts using
154 #ECCMID2018. The most influential tweeters are situated at the centre of different groups,
155 and the connecting lines are weighted by the strength of the connection [11]. The map displays
156 a predominantly “tight crowd” pattern formed by highly connected tweeters (G1-G4). This
157 very large and complex map has been included to demonstrate how connected the tweeters
158 were during ECCMID2018.

159

160 Venn diagram (Figure 2) has allowed us to classify users into tweeters, retweeters and those
161 mentioned and helped to distinguish the key users. Tweeter accounts in the central zone of the
162 Venn diagram, representing 4,8% of all accounts, were actively tweeting and also were
163 mentioned and retweeted. These were the most influential tweeters and as a result made up the
164 largest group of tweeters in the Congress summary [13] and were included in the sub-group
165 analysis for further evaluation. The number of influential accounts showed a modest 13%
166 increase in 2018 (from 127 to 144). The “just retweeted” category was the largest group (72%
167 of the active accounts in 2018), and the number of accounts in this category has substantially
168 increased from 1,167 in 2017 to 1,904 in 2018 (63% increase). These tweeters did not generate
169 their own content, but they were important in disseminating the information. According to the
170 Congress summaries [12, 13], the “just mentioned” category included speakers at the Congress,
171 international organisations like ESCMID, university departments, journals and journal editors
172 and made up the second largest group of Twitter accounts on the NodeXL map.

173

174 ***Independent predictors for retweets***

175 The components of a successful tweet were initially studied using univariable analysis based
176 on ECCMID2018 data. Overall, out of 3653 tweets 86% (n=3158) included one or more
177 additional components: 62% (n=2248) included an image (n=2163) or a video (n=85) which is
178 categorised as multimedia, 38% (n=1392) mentioned other tweeter users, 35% (n=1281) used
179 a non-conference hashtag, and 17% (n=634) included a URL. Fifty three percent of tweets
180 (n=1930) were posted by tweeters with less than 1,000 followers. As shown in Figure 3, there
181 was a stepwise increase in the number of retweets received with the inclusion of more
182 components. Based on this analysis, use of multimedia, number of followers, URL, and
183 mentions of other Twitter users were all positively associated with retweets and were selected
184 for multivariable analysis.

185

186 The impact of individual components of tweets, which were identified by previous component
187 analysis, was further studied by multivariable logistic regression analysis. The use of
188 multimedia (images and/or video), mentioning of other tweeters, the use of other hashtags, the
189 inclusion of an URL and the number of followers were all independently associated with
190 retweets (Table 2). However, the number of followers had significant interactions with mention
191 of other tweeters and also with inclusion of an URL. Despite inclusion of these interaction
192 terms into the model, all individual tweet characteristics remained significant. Based on this
193 observation a subgroup analysis was performed in tweeters with >1,000 followers and <1,000
194 followers. Mentioning other Twitter users and inclusion of multimedia were the only
195 independent predictors of retweets in tweeters with fewer than 1,000 followers, whereas among
196 tweeters with more than 1,000 followers all four tweet characteristics remained significant
197 predictors of retweets.

198

199 ***Sub-group analysis***

200 The top tweeters of the ECCMID2018 are shown in Supplementary table, which includes the
201 top influencer ESCMID, as well as a mixture of personal accounts, organisation and journal
202 accounts, and commercial companies. In this analysis, we compared the number of followers
203 of the top tweeters, the number of tweets they have posted, and the number of mentions and
204 retweets these accounts have received. ESCMID ranked the highest in each category. However,
205 we observed a discrepancy among other tweeter accounts. For instance, some accounts with
206 higher numbers of followers and tweets received fewer retweets than other accounts with a
207 smaller number of followers and tweets.

208

209 **Discussion**

210 In this study, we observed a substantial rise in retweet activity and a modest increase in the
211 number of influential Twitter accounts between two successive congresses. Although it is
212 difficult to ascertain the precise motives behind this enhanced activity through this analysis,
213 the findings indicate the importance of social media connections, which is displayed as “tight
214 crowd” pattern on the NodeXL map formed by highly connected tweeters i.e. ESCMID
215 account. Besides, during ECCMID 2018, the Trainee Association of ESCMID (TAE) steering
216 committee members, all physicians, were involved in the congress social media planning and
217 have actively tweeted from ESCMID and TAE twitter accounts, whereas during ECCMID
218 2017 mostly non-physicians were involved, which might have influenced the quality, content
219 and appropriateness of the tweets. This emphasises the importance of involving physicians and
220 scientists in outlining and implementing social media activity for medical congresses.
221 Additionally, these results highlight that there is an evolving interest in social media during
222 conferences. Many scientists indicate that they actively follow conferences remotely through
223 Twitter [3]; however, as observed in this study the main generators of content remain limited.
224 In 2018, approximately 13,000 delegates attended ECCMID, but only 591 Twitter accounts

225 actively tweeted about the Congress. In an era of widespread social media usage, there is a
226 reluctance by some scientists and physicians to use this medium.

227

228 Social media posts generated during these congresses reached a broader audience. In
229 comparison with a cardiology conference [15], ECCMID2018 had a more connected pattern of
230 tweeting. Besides, the median number of followers for Twitter accounts increased between
231 years. In a recent study on social media dynamics, scientists and physicians with over 1,000
232 followers have been shown to reach a more varied audience, including public and policymakers
233 [16]. This emphasises the function of Twitter as a potential outreach tool, considerably
234 increasing the overall reach of scientific messages [1].

235

236 Components and content of a tweet have a significant impact on the amplification of social
237 media posts. In a recent study, the inclusion of a URL was identified as the most critical
238 component in successful tweeting, whereas inclusion of an image was associated with less
239 retweet success [6]. Although inclusion of a URL was also important in our study, this was
240 only significant in the subgroup of users with over 1,000 followers. In comparison, the
241 inclusion of multimedia and mention of other tweeter(s) were the only consistent independent
242 predictors of a successful tweet in our study. Our component analysis in combination with
243 subgroup analysis highlights that Twitter success and influence requires a strategic and
244 tenacious performance, which is comparable with the findings from Cote et al. [16].

245

246 The most important limitation of this study relates to the intrinsic nature of social media
247 analytics. For example, it was not possible to quantify the number of people who viewed the
248 posts, nor to distinguish posts generated within or outside the congress hall or to identify the
249 motivations for tweeting and retweeting, and not tweeting. We may have missed some of the

250 congress related posts which did not include the official congress hashtag. In addition, our aim
251 was to determine the general characteristics of a successful tweet regardless of the topic;
252 therefore, we have not themed the tweets by topic, and also the numbers in the subgroups were
253 too small for adequately powered analysis. To expand this study and overcome some of the
254 limitations, tweets and replies without the congress hashtag could be included manually and to
255 allow this manual extraction the data could be extracted and shared immediately during the
256 congresses.

257

258 In conclusion, social media could help disseminate scientific messages beyond the congress
259 hall, if and when the posts constitute the right combination of components. Identifying ways to
260 support more physicians and scientists to tweet original content should be explored.

261

262 **Authors contributions**

263 MC and GM conceptualised this study, GM performed the network analysis, DO performed
264 the multivariable analysis. MC drafted the first and subsequent versions of the manuscript, and
265 all authors provided critical feedback and contributed to the manuscript.

266

267 **Financial support and sponsorship**

268 None

269

270 **Conflicts of interest**

271 MC was a Steering Committee member of Trainee Association of ESCMID at the time of
272 ECCMID 2018 and was actively involved in social media planning and implementation of

273 ECCMID2018. DO was a Steering Committee member of Trainee Association of ESCMID at
274 the time of ECCMID 2017 and ECCMID 2018.

275

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323 rooftops? *FACETS* 2018; 3(1): 682-94.
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325

326 **Table titles and legends**

327 Table 1. Overview and comparison of social media activity at ECCMID 2017 and ECCMID
328 2018

329 Table 2. Factors associated with retweets in multivariable analysis

330 Supplementary table: Top 20 tweeters from #ECCMID2018 (by number of retweets)

331 **Figure titles and legends:**

332 Figure 1. Network activity of ECCMID 2018

333 Figure 1 Caption: This figure illustrates the extent of connections. Each picture represents a
334 Twitter user who either tweeted, was mentioned, and/or retweeted posts using the
335 #ECCMID2018 hashtag. The map displays a predominantly “tight crowd” pattern formed by
336 highly connected tweeters (G1-G4).

337 Figure 2. Social media influencers tweeting, retweeting and mentioned in tweets using the
338 #ECCMID2018 hashtag

339 Figure 2 Caption: This Venn diagram summarises all the users involved in ECCMID2018
340 social media activity (n=2,973 accounts). It classifies users into tweeters, retweeters and
341 those mentioned and identifies most influential tweeters depicted in the center of the diagram.

342 Figure 3. Components of a successful tweet - univariable analysis

343 Figure 3 Caption: The components of a successful tweet were initially studied using
344 univariable analysis based on ECCMID2018 data. Variables of interest were: inclusion of
345 multimedia (images and/or video), a link to other information on the web (Uniform Resource
346 Locator (URL)), mention of other tweeter(s), the number of followers of a Twitter user and
347 use of hashtags other than the congress hashtag. There was a stepwise increase in the number
348 of retweets received with the inclusion of more components.

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353 **Table 1: Overview and comparison of social media activity at ECCMID 2017 and**
354 **ECCMID 2018**

| # | ECCMID 2017 | ECCMID 2018 | p-value |
|---|-------------|-------------|---------|
| Total accounts tweeting, retweeting and/or mentioned in tweets | 2,150 | 2,973 | - |
| Number of active tweeters | 590 (27%) | 591 (20%) | <0.001 |
| Number of accounts just tweeted | 276 (13%) | 214 (7%) | <0.001 |
| Number of all accounts RTed | 1,546 (72%) | 2,389 (80%) | <0.001 |
| Number of accounts just RTed | 1,167 (54%) | 1,904 (64%) | <0.001 |
| Number of accounts mentioned | 558 (26%) | 655 (22%) | <0.001 |
| Outcomes | | | |
| Number of tweets | 4,657 | 4,213 | - |
| Number of retweets | 7,818 | 12,109 | - |

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Table 2. Factors associated with retweets in multivariable analysis

| Tweet characteristic | All tweeters | All tweeters (with inclusion of interaction terms) | Subgroup analysis <1,000 followers | Subgroup analysis >1,000 followers |
|---|--------------------------|---|--|--|
| | Odds ratio (95% C.I.) | Odds ratio (95% C.I.) | Odds ratio (95% C.I.) | Odds ratio (95% C.I.) |
| Inclusion of media (video or picture) | 1.50 (1.30 – 1.74) | 1.53 (1.33-1.78) | 1.40 (1.14-1.72) | 1.76 (1.43-2.17) |
| Mention of other tweeters | 2.01 (1.75 – 2.32) | 2.19 (1.84-2.60) | 2.13 (1.76-2.57) | 1.67 (1.35-2.07) |
| Inclusion of other hashtags | 1.23 (1.07 – 1.42) | 1.20 (1.04-1.39) | 1.00 (0.82-1.22) | 1.66 (1.35-2.04) |
| Inclusion of URL | 1.42 (1.16 – 1.74) | 2.32 (1.77-3.03) | 1.28 (0.89-1.83) | 1.74 (1.37-2.21) |
| The number of followers (per 100 increase) | 1.01 (1.01 – 1.01) | 1.02 (1.02-1.03) | N.A. | N.A. |

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