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**SHORT REPORT**

# Network analysis of the social media activities around the #TeleCheckAF project

**Konstanze Betz [1,2,†], Joep Van Haren[3,4,†], David Duncker [5], Martin Manninger[1,6], Jos Lemmink[3,‡], and Dominik Linz [1,7,*‡]**

[1]Department of Cardiology, Maastricht University Medical Centre and Cardiovascular Research Institute Maastricht, P. Debyelaan 25, 6202 AZ Maastricht The Netherlands; [2]Netherlands Heart Institute, Utrecht, The Netherlands; [3]School of Business and Economics, Maastricht University, Maastricht, Netherlands; [4]Department of Marketing and Strategy, Hasselt University, Diepenbeek, Belgium; [5]Hannover Heart Rhythm Center, Department of Cardiology and Angiology, Hannover Medical School, Hannover, Germany; [6]Division of Cardiology, Department of Medicine, Medical University of Graz, Graz, Austria; and [7]Department of Biomedical Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, Norregade 10, 1172 Copenhagen, Denmark

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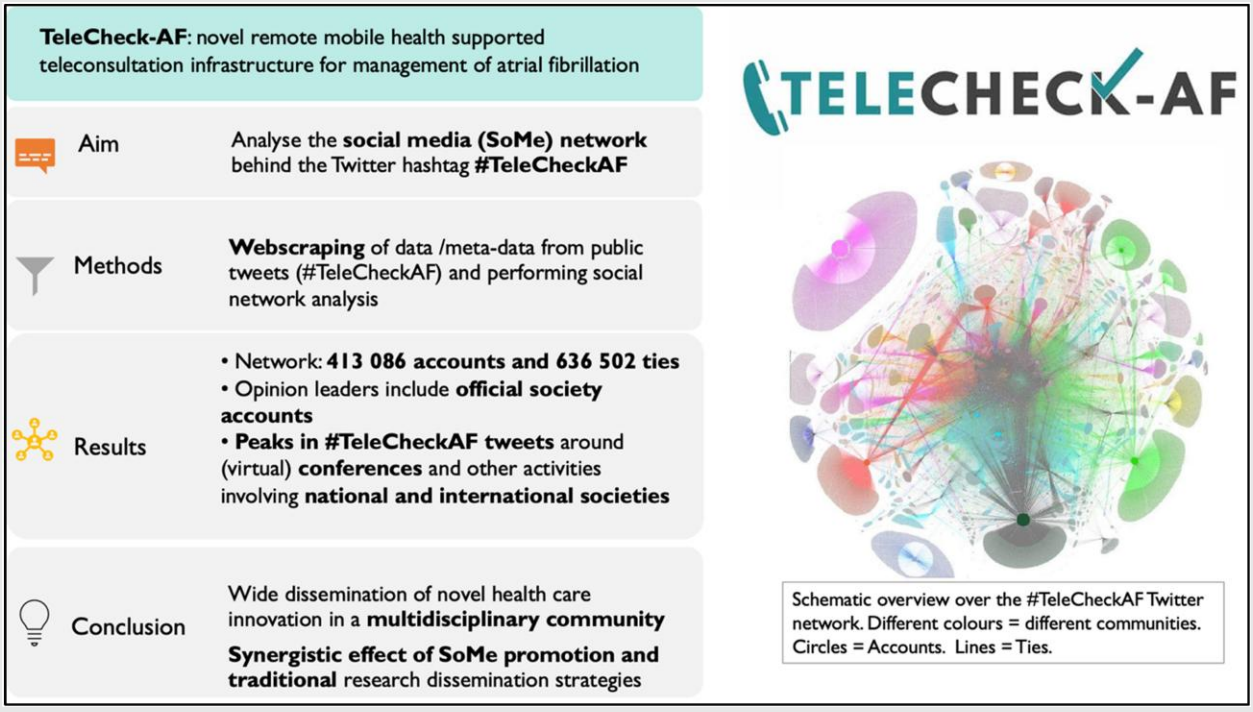
**Aims** TeleCheck-AF is a novel remote on-demand mobile health infrastructure around teleconsultations for patients with atrial fibrillation. Social media (SoMe) communication on Twitter contributed to the dissemination of this healthcare innovation by using the hashtag #TeleCheckAF. This study aims to analyse the SoMe network behind #TeleCheckAF and determine the key opinion leaders.

**Methods and results** Publicly available data on actors and interactions around the hashtag #TeleCheckAF were collected by web scraping from the platform Twitter. With tools based on social network analysis, a social network was created, different communities were identified, and key opinion leaders were determined by their centrality in the network. The SoMe network consisted of 413 086 accounts with 636 502 ties in 22 different communities. A total of 287 accounts that diffused information and/or used the TeleCheck-AF infrastructure were analysed in depth. Those accounts involved users from >15 different countries and multidisciplinary professions. Further, 20 opinion leaders were identified, including four official accounts of societies and associated journals among key opinion leaders. Peaks in #TeleCheckAF tweets were seen after (virtual) conferences and other activities involving national and international cardiology societies. Social network analysis of the TeleCheck-AF Twitter hashtag revealed a wide, multidisciplinary potential reach for the diffusion of a healthcare innovation.

**Conclusion** Official society SoMe accounts can amplify the dissemination of research findings by featuring abstract presentations during conferences and published manuscripts. This underlines the synergistic effects between traditional and SoMe-based research dissemination strategies for novel healthcare approaches, such as the TeleCheck-AF project.

* Corresponding author. Tel: +31 6 123 99 182, Fax: +31 43 3875093, Email: dominik.linz@mumc.nl
†The first two authors shared first authorship.
‡The last two authors shared last authorship.

## Graphical Abstract




**Keywords** Social media • Atrial fibrillation • mHealth • Healthcare innovation

The social media (SoMe) platform Twitter has emerged as a prominent communication platform for the European Society of Cardiology (ESC) and the subspeciality branches as well as their flagship journals.[1] Professional guidance by official Twitter handles and involvement of renowned researchers and specialists as Twitter ambassadors offer expert moderation and ensure incorporation of scientific evidence to SoMe discussions.[2]

Previous studies indicate a significant impact of a SoMe promotion strategy on journal and article metrics.[3] Nevertheless, for professional and effective use of novel dissemination strategies such as SoMe, their mechanisms and impact on the dissemination of research and healthcare innovations have yet to be fully explored and understood. In the presented short report, we unravel some mechanisms behind a SoMe-based dissemination of a healthcare innovation from a health professional perspective.

The TeleCheck-AF project is an example of successful dissemination of a research project and healthcare innovation through SoMe. TeleCheck-AF is a mobile health (mHealth)–based infrastructure around teleconsultations for patients with atrial fibrillation (AF). It comprises a structured teleconsultation ('Tele'), an app-based on-demand heart rate and rhythm monitoring ('Check'), and comprehensive AF management ('AF'). The infrastructure incorporates a CE-marked mobile phone app (FibriCheck®) utilizing photoplethysmography (PPG) technology through a smartphone's camera, allowing patients with AF to monitor their heart rate and rhythm (semi-)continuously around teleconsultations. Recordings are accessible to the treating physician through a secure cloud platform. This on-demand approach provides valuable heart rate and rhythm data for treatment decisions during teleconsultations and allows dedicated patient education and involvement.[4] To follow and archive the SoMe communication on Twitter around this project, the hashtag #TeleCheckAF was introduced. Within <2 weeks, the TeleCheck-AF infrastructure was implemented in 17 centres from six different European countries.[5] Eventually, 41 centres were included, and >6000 patients were treated according to the TeleCheck-AF approach. Dissemination of TeleCheck-AF happened rapidly—however, it took place amidst the challenges posed by the Covid-19 pandemic, including restrictions on travel and communication. We hypothesize that SoMe contributed to the fast dissemination of the healthcare innovation.

The aim of the study is to analyse the social network behind #TeleCheckAF to gain insight into the mechanisms driving the diffusion and to determine the key opinion leaders (OL), who have a central position within the social network. A SoMe network analysis centred around the hashtag #TeleCheckAF was performed. Data of accounts and their interactions within the #TeleCheckAF SoMe network were collected through web scraping, which is automatically capturing and extracting publicly available online information.[6] In case of the presented study, data were scraped from the SoMe platform Twitter by using the official academic Twitter package for R (academictwitteR), which utilizes official Twitter application programming interface (API). Scraped data included all public tweets that used the hashtag #TeleCheckAF, including their meta-data, replies, retweets, and quoted tweets. Additionally, followers and following lists of all accounts were included. The complete #TeleCheckAF network consisted of 413 086 accounts and 636 502 ties. Using the modularity algorithm of Gephi (Gephi - The Open Graph Viz Platform), we detected 22 communities within the network. Communities are groups of accounts (or nodes) whose connections are denser compared with the rest of the network.[7] Within the five biggest communities of the network,

**Table 1 Overview on centrality measurements**

| Centrality measurement | Description | Overall cohort mean (SD) | ESC journal account (*Z*-score) |
|---|---|---|---|
| Degree centrality ($n = 287$) | Number of ties (interactions) linked to a user. Accounts with high degree centrality can diffuse complex information rapidly. | 2243 (5968) | 51 624 (8.27) |
| Eigenvector centrality ($n = 286$) | Extended version of the degree centrality that considers also other user's connections. | 0.11 (0.11) | 0.47 (3.13) |
| Closeness centrality ($n = 286$) | Accounts closely located to other accounts in the network that can quickly reach many other accounts. | 0.27 (0.12) | 0.45 (1.39)[a] |
| Betweenness centrality ($n = 287$) | Serve as information brokers or connect otherwise disconnected groups in the network. | 2 160 529 (8 212 375) | 85 585 177 (10.16) |

After Mbaru and Barnes,[8] overall mean (SD) scores of 287 analysed nodes and exemplarily of one key opinion leader (ESC journal account). Closeness, eigenvector centrality score, and *Z*-score were rounded up to two decimal places.
ESC, European Society of Cardiology.
[a]Highest in analysed cohort.

we identified communities with a majority of electrophysiologists, with a majority of cardiologists, one with the biggest subgroup of professions in nursing, and one with a majority of professions in health technology. Further, we identified different geographical distributions of the communities both from countries in which TeleCheck-AF was implemented and countries in which it was not available. Overall, 287 Twitter accounts actively diffused #TeleCheckAF information ($n = 207$, 72%), adopted the TeleCheck-AF infrastructure ($n = 60$, 21%), or did both ($n = 20$, 7%). Based on publicly available data of those accounts, a majority of accounts originated from Belgium ($n = 42$, 14.7%), the UK ($n = 38$, 13.3%), Germany, and Austria ($n = 27$, 9.4%, respectively). These were followed by accounts from the USA and Oceania ($n = 24$, 8.4%, respectively) and the Netherlands ($n = 21$, 7.3%). The top three known professional backgrounds were electrophysiology ($n = 73$, 25.4%), cardiology ($n = 53$, 18.4%), and nursing and allied health professionals ($n = 24$, 8.3%), followed by research ($n = 17$, 5.9%) and health technology ($n = 16$, 5.6%). Interestingly, also four official patient advocate accounts were active in the SoMe network.

To identify OL, the position of the accounts in the network was evaluated by their centrality. Centrality is a measurement of the importance of a user's position in the network and impacts their contribution to the diffusion of an innovation. Interpretation of centrality is done with the help of centrality measures, with the most common researched measures: degree centrality, closeness centrality, and betweenness centrality.[8] Accounts with a high degree centrality have a high number of direct connections to other accounts. Those accounts can rapidly diffuse complex information. Degree centrality incorporates, next to other characteristics, the number of followers and can be differentiated into in-degree (incoming connections to a user) and out-degree (outgoing connections from a user), both of which were assessed within our study. Accounts with a high closeness centrality are closely located to other accounts in a network and can therefore quickly reach many other accounts. Accounts with a high betweenness centrality serve as information brokers or connect otherwise disconnected groups in the network.[8] In addition, we assessed the eigenvector centrality (extended version of the degree centrality that accounts also for other user's connections) and full shares (how many times a user created content). Following previous studies and literature,[9,10] OL were classified as those users whose centrality measure (for each centrality measure separately) was at least 2 SD above the mean score. Overall, 20 OL were identified. Notable is the presence of four accounts affiliated to the ESC among the OL. Two accounts were official ESC society and journal accounts, and two accounts were SoMe editors/supervisors for ESC or ESC journals. The official ESC journal Twitter account was an OL on three metrics (degree, betweenness, and eigenvector centrality) and showed the highest closeness centrality in the analysed cohort ($n = 287$; *Table 1*), highlighting its important position within the network and suggesting its high impact on the dissemination of #TeleCheckAF. This account featured publications around TeleCheck-AF (*Figure 1*), which included rapid communication about the TeleCheck-AF infrastructure and a description of its components and implementation.[4] An initial peak in #TeleCheckAF tweets was seen after a TeleCheck-AF feature on the society's educational website, tweeted by the official ESC society account. Further, peaks in #TeleCheckAF tweets appeared through activities of different national and international cardiac societies, at which TeleCheck-AF was discussed and featured on Twitter. These findings imply potential synergistic effects between traditional dissemination of healthcare innovation—by publication of research findings in acknowledged journals or conferences—and innovation dissemination through SoMe.

Overall, the #TeleCheckAF SoMe network analysis provided new insights into the mechanisms behind diffusion of research and healthcare innovations on SoMe to support the understanding of this innovative field of communication. Behind the hashtag #TeleCheckAF, a multidisciplinary social network was detected. This implies the wide interest in this healthcare innovation and communication between different geographical and occupational communities. These goals are traditionally also set through national and international congresses, where healthcare professionals can present and discuss their innovations. The official ESC journal account was positioned centrally in this network. Such OL can diffuse complex information (high degree centrality), spread information quickly (high closeness centrality), and serve as a bridge to otherwise disconnected parts of a network (high betweenness centrality). With this research, we provide an example on how OL can be identified in a social network. Professionals who want to disseminate healthcare innovations or research—in cardiology and beyond—can use similar approaches to identify and involve OL. The SoMe communication around TeleCheck-AF created awareness and discussions around this new healthcare innovation. By featuring abstract presentations during conferences through official Twitter ambassadors and publication of research in acknowledged journals with SoMe strategies, synergistic effects between traditional and SoMe-centred research dissemination strategies can amplify the potential reach for novel healthcare innovations. However, some limitations must be addressed. Only publicly available data were used, and only Twitter accounts who diffused information about or adopted TeleCheck-AF were analysed in-depth. A possibility for bias through incomplete or incorrect disclosure of information of accounts might have occurred. Further,

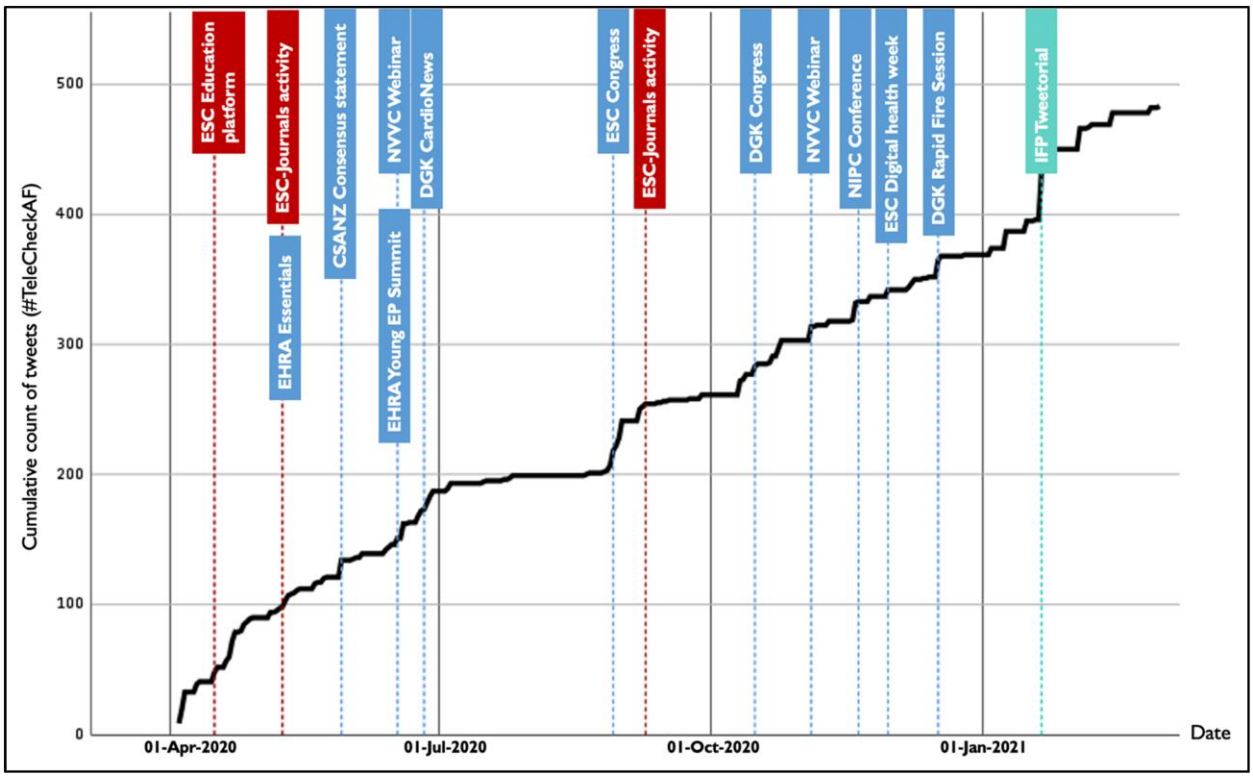



**Figure 1** Cumulative count of tweets (#TeleCheckAF) over time. Cumulative tweets including #TeleCheckAF. Activities (online congresses, webinars, and features) of national and international societies are included based on whether the TeleCheck-AF was presented and tweets including #TeleCheckAF were sent . In addition, Twitter activities of the official European Society of Cardiology society and journal handles are included (ESC Education platform, ESC-Journals activity). ESC, European Society of Cardiology; EHRA, European Heart Rhythm Association; CSANZ, Cardiac Society of Australia and New Zealand; NVVC, Dutch Society of Cardiology; DGK, German Society of Cardiology; NIPC, National Institute for Prevention and Cardiovascular Health Ireland; IFP, International Fellows Program.

data include limited availability of information on accounts with >100 000 followers, because the web scraping process allowed limited access to tweet data (based on the Twitter API), and large computational power would be required for processing data of users with this many followers. Future studies are necessary to comprehend the precise synergies between traditional and SoMe-based research dissemination strategies, the longitudinal development and interactions between SoMe promotion and real-life implementation of a healthcare innovation, and the long-term impact of SoMe dissemination strategies on the development of healthcare innovations.

**Conflict of interest:** K.B., J.V.H., and J.L. have no conflicts of interest to declare. M.M. received speaker fees from Bayer, Biosense Webster, Biotronik, Amomed, AOP Orphan, Boston Scientific, Daiichi Sankyo, and BMS/Pfizer and research grants from Biosense Webster and Abbott. None of those are relevant to the current work. D.D. received modest lecture honorary, travel grants, and/or a fellowship grant from Abbott, AstraZeneca, Biotronik, Boehringer Ingelheim, Boston Scientific, Bristol Myers Squibb, CVRx, Medtronic, Microport, Pfizer, and Zoll. Maastricht University received lecture honorary on behalf of D.L. from AstraZeneca, Bayer, Biotronik, Boehringer Ingelheim, Philips, Novo Nordisk, Biosense Webster, and Medtronic.

## Data availability

The data underlying this article will be shared upon reasonable request to the corresponding author.

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