Exploring public opinion about telehealth during COVID-19 by social media analytics

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Abstract
While COVID-19 catalyzed the acceptance and use of telehealth, our understanding of how it is perceived by multi-stakeholders such as patients, clinicians, and health authorities is limited. Drawing on social media analytics, this research examines social media discourses and users’ opinions about telehealth during the COVID-19 pandemic. It applies natural language processing and deep learning to explore word of mouth on telehealth with a contextualized focus on the COVID-19 pandemic. We conducted topic modeling, sentiment analysis, and emotion analysis (fearful, happy, sad, surprised, and angry emotions). The topic modeling analysis led to the identification of 18 topics, representing 6 themes of digital health service delivery, pandemic response, communication and promotion, government action, health service domains (e.g. mental health, cancer, aged care), as well as pharma and drug. The sentiment analysis revealed that while most opinions expressed in tweets were positive, the public expressed mostly negative opinions about certain aspects of COVID-19 such as lockdowns and cyberattacks. Emotion analysis of tweets showed a dominant pattern of fearful and sad emotions in particular topics. The results of this study that inductively emerged from our social media analysis can aid public health authorities and health professionals to address the concerns of telehealth users and improve their experiences.

Keywords
Telehealth, telemedicine, machine learning, social media analytics, COVID-19

Introduction
Telehealth is an effective model of service delivery in managing both communicable and noncommunicable diseases.\(^1\)–\(^3\) It remains a strategic digital health solution that enables health professionals to effectively deliver health services to citizens during public health crises. In particular, the benefits of telehealth for managing public health emergencies such as the COVID-19 pandemic include maintaining access to care while reducing person-to-person contact and resultant risk of viral infection.\(^4\)–\(^8\)

Understanding public opinion about the use of telehealth can contribute to the effective use of telehealth and consequently improve public health services during pandemics. A dominant approach by telehealth researchers for investigating public opinions is applying surveys and qualitative studies in a specific context or at a national level,\(^9\)–\(^13\) but very few have undertaken international or global investigations.\(^14\)–\(^16\) Hence, the telehealth literature needs a better understanding of public opinion about telehealth at the global level in the context of pandemics. User-generated content on social media platforms (e.g. Twitter) provides a rich source of data for exploring the voices of customers.\(^17\) Twitter as a social media platform is widely used by a variety of social actors including individuals and institutions to disseminate information and share experiences related to an issue of mutual concern (i.e. public health crises).\(^18\)–\(^19\)

While the social media discourse on the use of telehealth during COVID-19 exists, text analytics research that longitudinally analyzes public opinion about telehealth during COVID-19 is scant. Thus, to address this knowledge gap,
we aimed to explore the topics, sentiments, and emotions in user-generated content (tweets) about telehealth with a contextualized focus on public health crises. Consistent with our research aim, we sought to answer the question: “What are the social media discourses and user opinions about telehealth during COVID-19?”

Our analytics approach is an attempt to explore the emerging and diverse nature of telehealth use, and create value for public health scholars and practitioners. To our knowledge, this research is among the first social media analytics studies to comprehensively explore the public sentiments, emotions, and topics about the use of telehealth with a contextualized focus on COVID-19. This research, informed by user-generated content from social media, can aid public health authorities and health professionals to address telehealth customers’ concerns and improve their experiences. Furthermore, our results can inform the identification and management of fearful and angry emotions related to telehealth, and help its acceptance as a healthcare strategy.

**Research method**

Figure 1 shows the research process, consisting of three main steps: (1) data collection and text preparation, (2) topic development, and (3) topic profiling. In the first step, using keywords related to COVID-19 and telehealth, we first collected a dataset of posts from Twitter from 31 May 2020 to 15 April 2022. The following data items were extracted and used: time, tweet type, number of retweets, and tweet text. Then, we tokenized the tweets, and cleaned them by removing hyperlinks, mentions, and stop words (all the text preparation and machine learning techniques were applied in Python 3). We extended the stop words list by adding COVID-19 and telehealth as they were repeated in all the tweets. We applied lemmatization to generate word stems. Based on this process, our data was reduced. Then, the results were generated in the form of “bags of words” (BoW), indicating the frequency of each word per tweet.

In the second step, we modeled topics using the BERTopic library.20 We set the minimum size for topic development to 1000 tweets, which identified enough distinct topics and representative tweets for analysis. Tweets related to topics that did not meet the minimum size threshold were discarded. We also qualitatively analyzed the topics and their frequent keywords to merge the most relevant topics and shape the aggregate themes. Finally, we identified sentiments and emotions expressed in each tweet to develop topic profiles. We also referred to the original tweets and provided representative quotes for topic descriptions.

**Results**

Our data preparation resulted in 190,457 tweets with an average length of 16 characters. By setting the minimum topic modeling size, we identified 80,480 usable tweets. Eighteen emergent topics on telehealth during COVID-19 were identified via this approach. These topics are illustrated below and discussed as six overarching themes.

**Emergent topics discussed on telehealth during COVID-19**

A total of 18 first-order topics emerged from our topic modeling method. Table 1 shows frequent words, the label assigned to each topic, and illustrative tweets. We aggregated the topics into the following six themes:

1. **Digital health service delivery** theme covers tweets related to general reflections on virtual care, reporting events such as cyberattacks, discussing privacy and data protection issues in the context of telehealth, and
| Themes (aggregate dimensions) | First-order topics | Frequent words in each topic | Representative tweets |
|-------------------------------|-------------------|-----------------------------|------------------------|
| Digital health service delivery | 1. Virtual care | healthcare, pandemic, telemedicine, patient, care, health, digitalhealth, virtual, visit | In the midst of the transition to #telehealth during early days of the pandemic, we have seen evidence that the continuation of hybrid in-person/virtual healthcare is impactful. |
| | 2. Cyberattack | anonymous, hacker, intercept, dollar, lead, provided, reveals | As healthcare shifted to telehealth due to COVID-19, the industry became a bigger target for hackers making password management more important than ever. |
| | 3. Privacy | HIPAA®, security, cybersecurity, privacy, compliance, healthcare, data, secure, infosec | […] says he expects federal pay parity to remain for #telehealth, but not the flexibility to use non-HIPAA compliant means like Skype. |
| | 4. Access | broadband, internet, access, rural, learning, education, distance, reliable, need, digital | Technological tools have been at the forefront of the fight against #COVID19, not only providing access to essential and telehealth services, but also helping keep families connected while being socially distanced. |
| Pandemic response | 5. Test and vax | vaccine, vaccination, shot, health, testing, vaccinated, treatment, news, profit, unproven | Your health is important. Clinics & hospitals are taking precautions to protect patients from COVID-19, Telehealth options are available. Don’t delay routine exams, vaccinations, or well-child visits. |
| | 6. Lockdown | lock, season, nationwide, wait, prevention, possible, much, sick, available | Given our justified levels of distress in lockdown - and the volume of help needed - combined with cultural change toward telehealth during COVID - this just makes sense. |
| | 7. RAT® | obtain, antigen, various, official, reason, taking, number, rapid, tested | Did you know that accepted COVID-19 tests include both PCR and some antigen tests? An at home test can also qualify if it meets the CDC’s requirements, including being proctored by a telehealth professional. |
| Communication and promotion | 8. Media promotion | podcast, episode, listen, discuss, future, latest, industry, tdoc®, business, stock | In a recent Practice Made Perfect podcast, Drs […] discuss the #COVID19 pandemic […] how to prioritize patient safety while setting up telemedicine services. Listen here […] |
| | 9. Webinar | webinar, register, join, series, tomorrow, today, free, learn, discuss, session | You quickly scaled your #telehealth program in response to #COVID19 – what’s next? Join telehealth industry leaders from […] to learn how to sustain and grow your telehealth program. Register for the #webinar today: […] |
| Government action | 10 Legislative | medicare, emergency, public, coverage, congress, service, permanent, health, access | Rep. […], said before the amendment [to SB 3006a] passed that he wasn’t sure if he’d vote for the bill to ease the strain on hospitals from the current COVID-19 surge and increase access to telehealth if the amendment passed. |
| | 11. Financial | program, funding, application, round, million, additional, approved, commission, federal | State Reps. […] joined U.S. @[…] yesterday during a visit to Hancock Regional Hospital in Greenfield to discuss telehealth funding and programs supporting healthcare providers during the COVID-19 outbreak. |
| | 12. Trump | percent, unprecedented, realdonaldtrump, fighting, almost, give, quality, president | Telehealth use has increased by almost “9000 percent” during the COVID-19 pandemic. President @realDonaldTrump will keep fighting to give Americans unprecedented access to quality care when and where they need it! |
| Health service domain | 13. Mental health | mental, mentalhealth, health, pandemic, service, therapy, counseling, child, therapist | How to deal with normal school anxiety amidst covid. A mental health counseling practice using Clocktree telehealth has some tips. |
| | 14. Maternity | pregnancy, pregnant, woman, prenatal, sexual, baby, reproductive, carseat, newborn | Particularly during this time of COVID-19, pregnant people need every safe option available to care for their own bodies. The FDA approved the abortion pill 20 years ago. It’s time to make it available via telehealth. |
| | 15. Cancer | cancer, oncology, care, patient, | Yesterday, COA® released a position statement on |
The sentiment scores (positive, negative, or neutral) from our analysis are summarized in Figure 2. As evident from the first column (for all topics) in the figure, the majority (61%) of tweets about telehealth conveyed positive sentiments; 21% of the tweets were neutral, and only 18% had a negative sentiment connotation. Not surprisingly, topics 2 (cyberattack) and particularly 6 (lockdown) contain the most negative sentiments (26% and 86%). This is an example of a tweet with negative sentiment in the lockdown topic: “Given our justified levels of distress in lockdown - and the volume of help needed - combined with cultural change toward Telehealth during COVID - this just makes sense.” Interestingly, Twitter users were most positive about COVID-19 medications (topic 17 [pharmacy] with 92% positive sentiment). This is an example of these positive tweets: “[...] telehealth allows #YourNeighbourhoodPharmacists to monitor their patients’ chronic illnesses.”

**Pattern of emotions about telehealth during COVID-19**

Figure 3 plots the emotions (angry, fearful, happy, sad, and surprised) of telehealth and COVID-19-related tweets across the topics. Angry emotions were relatively similar across the topics as all topics are about COVID-19 and a certain level of anger is inevitable. One user mentioned: “The need is crying out for #telemedicine [in substance use disorder treatment]. There’s a technology and a treatment gap that’s growing”. Topic 18 (drugs) had a slightly higher percentage of angry tweets. The highest levels of fearful emotions were evident in topics 7 (RAT) and 17 (pharmacy). One user showed the “fearful” emotion by criticizing telehealth for critical conditions: “Telehealth has proven invaluable for people living with conditions such as MS during the COVID-19 pandemic”. Another user criticized the diagnosis they had received and mentioned: “My neck is extremely swollen (I get really bad strep throat & yes I already tested for COVID) and my new doctor on telehealth allowed me to see this swelling without having to make an in-person visit”. Another user critized the diagnosis they had received and mentioned: “My neck is extremely swollen (I get really bad strep throat & yes I already tested for COVID) and my new doctor on telehealth allowed me to see this swelling without having to make an in-person visit.”

Happy emotions were relatively similar across the topics. We noticed the lowest happiness scores in topics 6 (Lockdown) and 7 (RAT). One user expressed the benefits of telehealth during the pandemic: “COVID19 has affected so many aspects of our daily lives, but the rise of tele-health medicine has bolstered our ability to get you the care you need from the comfort of your home”.

### Table 1. Continued

| Themes (aggregate dimensions) | First-order topics | Frequent words in each topic | Representative tweets |
|-------------------------------|--------------------|-----------------------------|-----------------------|
| Pharma and drugs              | 16. Aged care      | older, adult, senior, aging, elderly, technology | The COVID-19 pandemic accelerated the transition of healthcare delivery from in-person to telehealth. While these strategies apply across patient populations, older patients, and particularly the home-bound frail elderly. |
|                              | 17. Pharmacy       | criterion, pharmacist, speaking, enough, parent, prescribe, paxlovid, hard, others | [...] telehealth allows #YourNeighbourhoodPharmacists to monitor their patients’ chronic illnesses. |
|                              | 18. Drugs          | addiction, opioid, treatment, disorder, substance, pandemic, overdose, drug, recovery | The shift to using #telehealth for medication-based treatment for #opioid use disorder is especially groundbreaking — and, some would argue, overdue. |

*COA: Community Oncology Alliance; HIPAA: Health Insurance Portability and Accountability Act; RAT: Rapid Antigen Test; tdoc: Teladoc; SB 3006: An Act relating to response to COVID-19.*
The highest levels of sad emotions were evident in topics 6 (Lockdown) and 12 (Trump). The highest level of surprise was evident in topic 2 (cyberattack). One user tweeted: “Telehealth vendors are fighting off many more cyberattacks than before COVID-19”. Along these lines, one user provided surprising news related to the benefits doctors have received due to telehealth: “In just two months, America’s Frontline Doctors helped rake in an estimated $6.7 million in consultation fees as part of a Hydroxychloroquine and Ivermectin telemedicine grift”.

Discussion

Our study extends the telehealth literature using social media analytics. It relies on longitudinal data and multiple methods of investigation (sentiment, topic modeling, and emotion analyses) to unpack public opinions. It also draws attention to the public value of telehealth in different health service domains (e.g. mental health, maternity, cancer care, and aged care). Our topic modeling analysis led to the identification of 18 telehealth-centric topics. These topics represent six themes related to digital health, pandemic response, communication and promotion, government action, health services, and pharma and drugs. The sentiment analysis revealed that while most tweets were positive, the public expressed mostly negative opinions about certain aspects of the pandemic and telehealth such as lockdowns and cyberattacks. Emotion analysis of tweets showed a dominant pattern of fearful and sadness in particular topics. The sentiment analysis and topic modeling that inductively...
emerged from our social media analysis can help public health authorities and health professionals to address telehealth users’ concerns and improve their experiences.

Our topic modeling approach highlighted the role of telehealth in transforming healthcare services. According to telehealth literature, during the pandemic, an increase in telehealth visits helped public health authorities manage the pandemic crisis and reduce the risk of COVID-19 transmission. Telehealth also supported the business continuity of the healthcare industry.

As the pandemic creates unprecedented challenges for public and healthcare networks, our findings echo the need for further government action to facilitate telehealth transformation and facilitate its continued use during the pandemic and post-COVID-19 era. For example, as reflected in our results in the “government action theme”, removing restrictions on telehealth visits is viewed positively and can ease the pressure on healthcare ecosystems during pandemics. Also, as revealed in our topic modeling, actions such as government administration, legislating, and reimbursement are potentially useful for success in telehealth. In response to COVID-19, many governments and regulators tried to expand the use of telehealth by introducing new reimbursement channels, and temporarily relaxed certain privacy requirements in order to improve public access to healthcare services. For instance, according to the notification of enforcement discretion of the US Office for Civil Rights, healthcare providers during the pandemic will not be subject to penalties for violations of the Health Insurance Portability and Accountability Act (HIPAA) if they provide telehealth services in good faith.

Thus, an increase in acceptance and use of telehealth during COVID-19 empowered healthcare entities to continue their businesses, while reducing exposure to COVID-19, and spread of the disease.

While the COVID-19 pandemic has presented new challenges to the global economy, it has increased telehealth awareness among providers and consumers as a new pathway in healthcare provision. During the pandemic, many healthcare institutions and telehealth practitioners raised awareness and promoted the use of telehealth via digital media such as webinars and podcasts, as illustrated in our communication and promotion theme analysis. Health informaticians and telehealth researchers have largely examined the use of telehealth during COVID-19 from clinical and economics perspectives. These investigations on telehealth, and its associated benefits and challenges, provide insightful knowledge on the role and complexities of telehealth acceptance and effective use during pandemics. Our mixed-methods approach extends the current telehealth literature and social media analytics. Consistent with stakeholders’ views, we also shed light on the considerations of multiple actors (e.g. patients, legislators, governments, and healthcare professionals) for telehealth success in future public health emergencies. Our findings reflect the views of communities of telehealth stakeholders (from healthcare providers to end users) on social media, what telehealth topics they cared about, and what triggered their emotions about telehealth use during the pandemic. Understanding negative and positive sentiments about telehealth can help providers to enhance telehealth experiences and reduce users’ resistance to telehealth use. Public health organizations can also use our approach and method to make sense of public reactions to health transformation programs and policies, and make timely adjustments based on public feedback. Our study, beyond its implications for practice, has potential implications for research as well. With the massive data available from social media, traditional qualitative methods may not be sufficient to analyze such a trove to provide insights. The novel machine learning approach used in our research, starting from the first-order topics and then their aggregation, is a guide to researchers who would like to harness the power of machine learning techniques.

Although we conducted social media analytics to understand important topics about telehealth during the COVID-19 pandemic, our research is limited in three ways. We used just one source of social media, although an important source, for machine learning-enabled analytics. Future research can use our methodological approach to advance telehealth topic modeling with multiple social media sources (e.g. Facebook and online forums). Second, we studied the broad topic of telehealth use in the COVID-19 context. Future research could benefit from investigating user opinions about multiple interrelated digital health systems (e.g. telehealth, mobile health, and medical artificial intelligence) in more specific contexts (e.g. telemental health and telerehabilitation). Third, in constructing the first-order topics, we relied on machine intelligence to understand telehealth use. Although our approach has a methodological fit to analyze big social media data, it would be beneficial for future research to conduct qualitative studies and global surveys to understand telehealth users’ experiences during COVID-19 and post-pandemic.

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