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Application of Social Network Analysis of COVID-19 Related Tweets Mentioning Cannabis and Opioids to Gain Insights for Drug Abuse Research

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Abstract. We applied social network analysis (SNA) to Tweets mentioning cannabis or opioid-related terms to publicly available COVID-19 related Tweets collected from Jan 21st to May 3rd, 2020 (n= 2,558,474 Tweets). We randomly extracted 16,154 Tweets mentioning cannabis and 4,670 Tweets mentioning opioids from the COVID-19 Tweet corpora for our analysis. The cannabis related Tweets created by 6,144 users were disseminated to 280,042,783 users and retweeted 11 times the number of original messages while opioid-related Tweets created by 3,412 users were disseminated to smaller number of users. The opioids Twitter network showed more cohesive online group activities and a cleaner online environment with less disinformation. The cannabis Twitter network showed a less desirable online environment with more disinformation (false information to mislead the public) and stakeholders lacking strong science knowledge. Application of SNA to Tweets provides insights for future online-based drug abuse research during the outbreak.

Keywords. social media, pandemic, cannabis, opioids, drug abuse

1. Introduction

One in nine Americans use illicit drugs. Approximately $740 billion are estimated for cost related to illicit drug abuse in the U.S [1]. Illicit drugs such as marijuana or cocaine stimulate or inhibit the central nervous system to cause hallucinogenic effects. Although the FDA has not approved a marketing application for cannabis for the treatment of any

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disease or condition except one, where its use is strictly controlled, there are products available on the market [2]. Drug abuse behavior is associated with stress, poor mental health status, poor ability to relate to others and poor social support [1]. Drug abuse behaviors are likely to be worsening during the COVID-19 pandemic [3]. Network analysis, based on the formalism of graph theory, is commonly used to characterize and understand relational data in a variety of scientific fields [4]. When applied to Tweet data, social network analysis may be used to identify key Twitter users and Tweets, as well as the relations between them, based on the structure (topology) of networks of Tweets and retweets [5]. In the context of a global pandemic, several measures of network centrality, including degree (the entities with the most links to other entities) and betweenness centrality (a broker of indirect connections among all others, a gatekeeper of information flow) may be particularly useful in detecting the spread of information or disinformation (disinformation/inaccurate information is shared deliberately while misinformation is shared accidently) on illicit drugs. The purpose of the study was to apply social network analysis on COVID-19 related Tweets mentioning cannabis and opioids to gain insights for future Twitter-based illicit drug abuse intervention and development of algorithms during the pandemic.

2. Methods

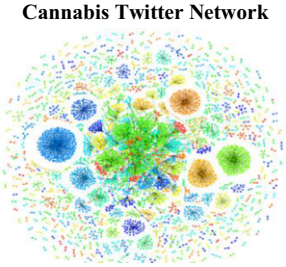
We applied SNA techniques on a publicly available Tweet corpus mentioning COVID-19 (keywords: covid19, Covid, covid-19, COVID, corona, coronavirus). We used the Twitter API, ORA and a Terremoto High Performance Computing Cluster. We extracted publicly available Tweets mentioning COVID-19 related terms (n= 2,558,474 Tweets) from Tweet corpora collected daily using an API from Jan 21st to May 3rd, 2020. First, mental health and behavioral science experts and clinicians in our team randomly extracted 16,154 Tweets mentioning cannabis (keywords: cannabis, marijuana, #CBD, weed, hemp, CBDoil) and 4,670 Tweets mentioning opioids (keywords: morphine, heroin, oxycodone/OxyContin/Percocet, hydrocodone/Vicodin, Norco, codeine, fentanyl, methadone, buprenorphine, Probuphine) from the initial COVID-19 Tweet corpora for our analysis to assess information or disinformation dissemination online behavior on cannabis during the COVID-19 pandemic [1]. Second, we applied SNA to Tweets mentioning cannabis and opioids to automatically detect the similar groups and to identify stakeholders on the topics within Twitter [4,5]. Girvan-Newman algorithm was selected after evaluating the utility of four clustering algorithms (Concor, Newman, Principal Component, and Louvain). The algorithms were considered less effective for the following reasons: 1) Concor: subjectivity and inefficiency of parameter settings as applied to the clustering process; 2) Principal Component: results included a large cluster consisting of 1662 users, which was less meaningful for clinical interpretability; 3) Louvain: modularity score was similar to Newman's algorithm, yet it included more clusters with only two users. Network measures to characterize the networks including density, size, and centralities of top stakeholders were computed using ORA. Third, we visualized the detected groups using a network diagram. Lastly, mental health and behavioral science experts and clinicians interpreted the results as disinformation (inaccurate information deliberately shared by the stakeholders) or as information (accurate information) according to clinical meaningfulness for use in future online interventions.

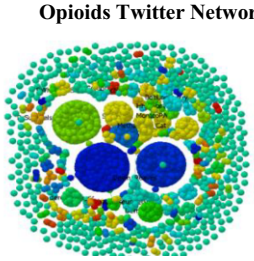
3. Results

The cannabis related Tweets created by 6,144 users were disseminated to 280,042,783 users and retweeted by 11 times the number of original messages. Similarly opioids related Tweets created by 3,412 users were disseminated to 496,010 users and retweeted 106 times the number of original messages. The top 10 stakeholders who disseminated information and disinformation about cannabis and opioids during the COVID-19, were identified as the media (CNN, Financial Times, High Times Magazine), actors, lobbyists, one individual, and organizations (a private funding agency, a football association) in the cannabis Tweet corpora ; and a journal (Nature), the media (AP, CNN, PBS), individuals and a sportsman in the opioids Tweet corpora (Table 1).

Table 1. Top 10 stakeholders in COVID-19 related publicly available Tweets mentioning cannabis and opioids (unit: 10^5)

Rank	Cannabis	Centrality	Opioids	Centrality
1	CNN	16.28	nature	300
2	FinancialTimes	9.24	Individual 3	19.05
3	rainnwilson	9.16	morphine_prince	18.45
4	Individual 1	8.14	Individual 4	14.66
5	Individual 2	8.14	jr_heroin	14.66
6	ACLU	5.62	CNN	14.1
7	goal	5.17	detroitnews	7.848
8	HIGH_TIMES_Mag	3.46	AP	4.142
9	NORML	1.95	Individual 5	2.25
10	Weed_Investor	1.59	ThaiPBS	1.684





	Entire network	Core network	Entire network	Core network
Users	6,144	254	3,412	12
Density	$10.6*10^{-5}$	0.0078	$24.58*10^{-5}$	0.104

Figure 1. Social networks on COVID-19 Tweets mentioning cannabis and opioids

A total of 622 distinct groups (n=6,144 users) was detected in the cannabis Tweet corpora (Newman modularity 0.89) and a total of 161 distinct groups (n=3,412) was detected in the opioids Tweet corpora (Newman modularity 0.34). The cannabis Tweet network contained 80% small subgroups (498 subgroups) and 5% large subgroups (32 subgroups). Similarly, the opioids Tweet network contained 88% small subgroups (141 subgroups) and 7% large subgroups (11 subgroups) (**Figure 1**). Topics detected within the cannabis Tweets include disinformation on COVID prevention or cures, promoting cannabis use behavior, buying, and delivery methods such as vaping or eating. Topics discussed within the opioids Tweets include the opioids crisis, fake cures, addiction on morphine, methadone and oxycontin, criminal justice, drug trafficking, and fentanyl shortage during the COVID-19 pandemic.

4. Discussion and Conclusions

This study found that information or disinformation (inaccurate information is shared deliberately) regarding cannabis created by 6,144 users were disseminated to 280,042,783 users and retweeted an average of 11 times the number of original messages (n=16,154) in Twitter during the outbreak. On the contrary, less number of the members (n= 3,412 users) disseminated information and disinformation regarding opioids to 496,010 Twitter users. Although the opioid Twitter network included a lower number of users reaching out a smaller number of audience Twitter users, the opioids Twitter network showed greater online group cohesiveness with higher activity within the network. The opioids Twitter network reflected a cleaner online environment with less disinformation than the cannabis Twitter network. To date, with the exception of one cannabis-derived drug product, the FDA has not approved a marketing or the use of cannabis for the treatment of any disease or condition. This exception is strictly controlled requiring a prescription from a licensed healthcare provider [2]. Yet the cannabis Twitter network were filled with disinformation including the use of cannabis for COVID prevention and treatment. The cleaner and healthier network environment with less disinformation of the opioid Twitter network could be explained by the characteristics of the top stakeholders of the network. Whereas both networks contained similar amount of regular individuals who constantly disseminated disinformation, the opioid Twitter network included a top stakeholder grounded in sound scientific foundation (Nature). Unlike the opioids Twitter network, the cannabis Twitter network included a top stakeholder as an entity with less scientific foundation (CNN). Further, the cleaner environment of the opioid network maybe explained by users' adherence behavior on the Twitter rules and policies. The authors suggest that the scientific entities grounded with evidence and rigorous methods are strongly encouraged elevating their social media presence during the pandemic. This study found that the betweenness centrality algorithm was able to detect more hidden gatekeepers of information and disinformation on illicit drug use during the COVID-19 than degree centrality algorithm. Betweenness centrality algorithm calculates the shortest path between every pair of nodes in a connected graphs and entities with high betweeness centrality are able to connect different groups [4]. The authors suggest that SNA with degree and betweenness centrality calculation methods would be beneficial to intervene information and disinformation for future online-based illicit drug use research during the outbreak [4].

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