Title: The Volume and Tone of Twitter Posts About Cannabis Use During Pregnancy: A Scoping Review Protocol

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Current word count: 2300

Abstract

Background: Cannabis use has increased in Canada since its legalization in 2018, including among pregnant women who may be motivated to use cannabis to reduce symptoms of nausea and vomiting. However, a growing body of research suggests that cannabis use during pregnancy may harm the developing fetus. As a result, patients increasingly seek medical advice from online sources, but these platforms may also spread anecdotal descriptions or misinformation. Given the possible disconnect between online messaging and evidence-based research about the effects of cannabis use during pregnancy, there is a potential for advice taken from social media to cause harm.

Objectives: To quantify the volume and tone of English-language posts related to cannabis use in pregnancy from January 2012 to July 2021.

Methods: Modelling published frameworks for scoping reviews, we will collect publicly available posts from Twitter that mention cannabis use during pregnancy and employ the Twitter Application Programming Interface (API) for Academic Research to extract data from tweets, including public metrics such as the number of likes, retweets and quotes, as well as health effect mentions, sentiment, location and users interests. These data will be used to quantify how cannabis use during pregnancy is discussed on Twitter and to build a qualitative profile of supportive and opposing posters.

Results: The CHEO Research Ethics Board reviewed our project and granted an exemption in May 2021. As of September 2021, we have gained approval to use the Twitter API for Academic Research and have developed a preliminary search strategy that returns over 2 million unique tweets posted between 2012 and 2020.

Conclusions: Understanding how Twitter is being used to discuss cannabis use during pregnancy will help public health agencies and healthcare providers assess the messaging patients may be receiving and develop communication strategies to counter misinformation, especially in geographical regions where legalization is recent or imminent. Most importantly, we foresee that our findings will assist expecting families in making informed choices about where they choose to access advice about using cannabis during pregnancy.

Registration: osf.io/6fb2e

Keywords: cannabis; pregnancy; health information; social media; Twitter

Introduction

Recreational cannabis use has increased in Canada since its legalization in 2018, including pregnant women[1]. Reductions in the perceived harms of cannabis use may occur around legalization, and, as a result, pregnant women or individuals may find the activity to be low risk[2]. Cannabis and its derivative products are often marketed online as safe. Certain groups and dispensaries may even promote the use of cannabis products during pregnancy for their anti-nausea and anti-emetic effects[3,4]. Expecting mothers may also use the drug to stimulate appetite or treat depression, motivated by the perception that cannabis is natural and thus preferable to prescription medications[5]. However, a growing body of research suggests that cannabis and derivative products during pregnancy may harm the developing fetus. Cannabinoids readily cross the placenta and interfere with the endogenous cannabinoid system, a cell-signalling network that assists in neurodevelopment[6]. Consequently, maternal cannabis use has been associated with fetal growth restriction, higher rates of childhood affective disorders, and a greater incidence of learning disability and autism spectrum disorders among offspring[7–9].

Pregnant patients are increasingly seeking medical and health advice on online platforms, especially for emerging topics like cannabis use[10,11]. While medical professionals and research groups may utilize these avenues to promote research findings, other Twitter users may employ social media to promote commercial interests, share anecdotal stories, or spread misinformation[12–14]. For example, a 2019 study by Ishida et al. found that those who primarily rely on social media for their health information were 31% more likely than others to endorse the claim that cannabis use during pregnancy is safe and 56% more likely to endorse any form of misinformation about cannabis[15].

Given the possible disconnect between online messaging and evidence-based research about the effects of cannabis use during pregnancy, there is a potential for advice taken from social media to cause harm to mothers and their babies. Thus, we propose a systematic search of Twitter to quantify the volume and tone of posts on the forum related to cannabis use in pregnancy. We will assess regional correlations in these data to determine if changes in the legalization of non-medical cannabis affect online messaging of its use during pregnancy in Canada and in states in the United States that have legalized recreational cannabis.

Methods

With reference to Arksey and O'Malley's framework for scoping reviews, we will synthesize publicly available posts from Twitter to determine how cannabis use during pregnancy is being discussed on the platform[16]. The steps, as outlined by this framework and adapted for a Twitter-based analysis, will be:

1. Identifying the research question
2. Identifying relevant Twitter posts
3. Selecting eligible Twitter posts
4. Charting the data
5. Collating, summarizing, and reporting the results

Past research from Cavazos-Rehg et al. has identified Twitter as a good source for analyzing online discussions about cannabis use because of its popularity and acceptance of substance use disclosure[17]. We will use this to model a novel scoping review approach to explore Twitter posts about cannabis use during pregnancy. We will report our findings following the PRISMA extension for scoping reviews (PRISMA-ScR)[18].

Step 1: Identifying the research question

How is cannabis use during pregnancy discussed on Twitter, regarding the volume, tone, content, and origin of posts?

Step 2: Identifying relevant Twitter posts

Our search strategy will follow an iterative approach according to our Population, Concept, and Context of interest (**Table 1**). We will first use Twitter's native search function to conduct a preliminary scan of English language Tweets about cannabis use during pregnancy and assemble a list of commonly used keywords and hashtags based on our findings. We will then refine our list to capture the breadth of online discussion while excluding mimicker terms (e.g., non-drug-related uses of the word "high"). Finally, our search strategy will include a list of terms for pregnancy combined with terms for cannabis to search the Twitter Application Programming Interface (API) (**Table 2**). For example, (pregnancy OR pregnant OR prenatal) AND (cannabis OR weed OR pot OR marijuana OR) with final search strategy to be developed following preliminary findings. We will use the Twitter API for Academic Research for data collection. We will perform a full archive search of all English language tweets containing the keywords of interest posted from January 2012, when Colorado became the first English-speaking jurisdiction to legalize cannabis, to July 2021[19].

Table 1 Population Concept Context (PCC) Framework

PCC Element	Definition

Population	Twitter posts containing information relevant to pregnancy and/or pregnant individuals.
Concept	Discussion or mention of cannabis use in relation to pregnancy and/or the developing fetus.
Context	All English-language Twitter posts (Tweets) made from January 2012 to July 2021. Geographical analyses will be restricted to Canada and states in the United States where recreational cannabis use is legal.

Table 2 List of keywords related to cannabis use in pregnancy used to search the Twitter Application Programming Interface

Keyword category	Keywords
Pregnancy-related	pregnancy, pregnant, baby, fetus, fetal, prenatal, perinatal, womb
Cannabis-related	cannabis, weed, pot, marijuana, marihuana, MJ, ganja, purp, bud, keef, kief, dope, "mary jane", thc, cbd, cannamom, opiate, mdma, ecstasy, mmj, medical marijuana

Table 3 Queries passed to the semantic search of Sentence-BERT

Queries	
Cannabis during pregnancy	Kids, child and youth smoking cannabis
Smoking weed while pregnant	Medical cannabis for people
The effects of cannabis on pregnant women	Legalization of cannabis

Smoking or consuming drugs during pregnancy	
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Step 3: Selecting eligible Twitter posts

Following the Twitter Archive search, we will pre-process the corpora to filter out content unrelated to cannabis use during pregnancy. Additionally, we will remove bot accounts, and tweets without geotags are further analyzed to infer a location from their authors' profile (**Figure 1**). We will filter all tweets containing our keywords but are unrelated to the consumption of cannabis during pregnancy via a *semantic search* using Sentence-BERT[20]. This search assigns a score to each tweet for each given query (**Table 3**). The higher the score, the more semantically close the tweet to the query. Tweets with a score lower than 0.6 for all queries are discarded since they are likely unrelated. We will also use a topical context analysis to provide meaning and classify tweets by performing a *semantic community detection* using Sentence-BERT[20]. We will set the minimum size of communities (or clusters) to 10 for this classification and a threshold similarity of 0.6. Clusters will contain at least ten tweets, and the similarity between tweets of the same cluster will be at least 60%. We will further classify related tweets into broad categories related to (1) cannabis during pregnancy-related and (2) medical cannabis-related or cannabis and youth-related, or legalization of cannabis. In addition, we will classify tweets related to cannabis during pregnancy into commercial, anecdotal/conversational/babble, misinformation, memes, and research studies.

We will proportionally sample a pre-defined number of the returned tweets from each week of the search period (not exceeding 5000 in total but subject to change according to resource constraints). Two independent reviewers will assess these tweets for inclusion based on pre-

defined eligibility criteria. As per our PCC criteria, we will include tweets if they discuss cannabis use during pregnancy and are written in English. Tweets will be excluded in following the exclusion criteria defined in Step 2. During the screening process, regular meetings with a senior investigator will be held to resolve discrepancies and, if necessary, to further refine our inclusion and exclusion criteria.

Step 4: Charting the data

Data charting will include an automated analysis of all tweets returned by our search. A manual analysis will then be conducted on the smaller subset of tweets included during the process outlined in Step 2.

Using the Twitter API for Academic Research[21], we will collect the timestamp of each returned tweet and analyze its text for sentiment (positive or negative) by integrating with the Natural Language Toolkit (NLTK) in Python and other techniques such as latent dirichlet allocation[22], Sentence-BERT[20], or recurrent neural networks[23]. We will also analyze the number and types of health effects mentioned in association with cannabis use in pregnancy and will extract location data where available from each tweet, either from geo-tagged tweets or from the location associated with the user's profile[24].

Two independent reviewers will manually review the smaller subset of randomly sampled included tweets. Data will be extracted using a pilot-tested Excel form. We will verify the number of favourites and retweets each tweet has received against the automatic data collection via the API. We will use publicly available user lists[25] to determine the category of organization or individual user that posted the tweet (government or public health agency, obstetrical society/network, university, hospital, news outlet, cannabis industry source, or

other individual)[26], and we will manually assign a category for organizations not appearing the user lists. Finally, we will assess if the Tweet mentions positive or adverse health effects on mothers or developing fetus/infants, and the specific health effect(s) mentioned. For each tweet, data will be extracted by one reviewer and validated by a second reviewer. A third independent reviewer will resolve discrepancies if they arise.

During this process, the review team will also identify influential accounts contributing to the discussion to develop a qualitative profile of those who support and those who oppose cannabis use during pregnancy.

Separately, we will also extract CENSUS or population-level data on birth rates and maternal and infant mortality rates across the study period in Canada and the United States. These vital statistics data will be sourced from Statistics Canada and the Centers for Disease Control and Prevention in the US[27,28].

Step 5: Collating, summarizing, and reporting the results

We will first report the total number of tweets returned over the search period and temporal trends in the number of tweets posted over the study period. Next, the number of tweets sampled in the automated and manual analyses will be reported. From the automated analysis, we will report the number (n) and percentage (%) of the returned posts that discuss cannabis use during pregnancy positively or negatively as determined by our sentiment analysis. Subsequently, we will calculate the standardized mean difference in the number of favourites and retweets received by positive and negative tweets, and to compute the odds (ratio) that positive posts (a) originate from each category of organization or individual and (b) mention health effects. We will further calculate the number of times each health effect was

mentioned as a percentage of the total health effect mentions. These statistics will be presented in tabular form.

The location-based component of our analysis will be restricted to tweets that offer location data and originate from Canada and legal states within the US, as these are the only English-speaking regions that have legalized the sale of non-medical cannabis. If any regions (e.g., New Zealand, United Kingdom) legalize cannabis before our analysis is conducted, this restriction will be changed to include them. We will match location data from these jurisdictions to the timestamp for each tweet to calculate the proportion of tweets originating from our pre-defined geographical regions for each week of the search period. Next, we will visualize each region on a line graph that plots time vs. the volume of posts with a marker to indicate when that region legalized cannabis. A line graph that plots time vs. percentage of positive posts will be plotted using the same process. We will then use a repeated cross-sectional design to analyze the correlation of these data with population-level vital statistics data and determine if trends in cannabis messaging on Twitter correlate with birth rates and maternal and infant mortality rates.

In addition to these numerical analyses, we will develop qualitative profiles of influential accounts. These profiles will include elements such as the user's background (e.g., political leaning, socioeconomic status, education/interests), their Twitter following, whether Twitter has verified their account as "authentic, notable, and active"[29], and how they contribute to the discussion about cannabis use during pregnancy on the platform. Comparisons and contrasts will be drawn between the typical supportive and opposing posters on the basis of these elements.

Ethics and Dissemination

This study was exempted from ethics review on the basis that it will collect and synthesize publicly available data. It therefore does not require ethics approval.

Results

Using our data collection method, combining the `search_all_tweets` function from `tweepy` together with the Twitter API for Academic Research, we collected 2M tweets and 1M retweets that are potentially related to cannabis use during pregnancy. These results cover all English-language tweets posted from 2012-01-01 to 2021-08-01 (9 years and 7 months) that include both *pregnancy* and *cannabis* related keywords. **Figure 2** shows the distribution of all 3M tweets per day since 2012. Colorado was the first English-speaking jurisdiction to legalize cannabis in 2012, and Canada legalized cannabis in 2018. Out of the 2M unique tweets, only 4.3% of them are geo-tagged (**Figure 3**). Note that these tweets are concentrated mainly in English-speaking cities or countries. This finding is expected since our search explicitly requested English tweets. Our Twitter search includes 29 distinct keywords; we plotted the number of times each keyword appears in our corpora (**Figure 4**).

The semantic community detection algorithm detected 220 clusters within the 2M tweets from our corpora. We manually inspected the top-5 and bottom-5 tweets of each cluster and assigned an appropriate label that best described the topical context of those tweets. For example, we found 9 topical clusters related to *cannabis use during pregnancy* (**Figure 5**). A sample of tweets from one identified cluster, “Cannabis exposure on infants,” is shown (**Table 4**).

Table 4 Top-3 and bottom-3 tweets selected from the cluster “Cannabis exposure on infants”

Tweet #	Tweet
1	strange reason for baby positive pot test found random thc in baby soap
2	baby soap triggers positive marijuana test in newborns
3	baby soap and marijuana are linked and causing false positive drug tests in newborns babies
...	...
45	you need help baby all doing is absorbing some thc
46	great thanks dave the last one saw from pediatric doctor was advising that mothers can pass thc through the placenta and breast milk which was thought to potentially harm baby brain development
47	the clinician researcher to watch regarding thc exposure during pregnancy is dr tori metz at denver health

Discussion

This study will infer how cannabis use in pregnancy is portrayed on Twitter, the content and origin of supportive posts, and how legal status changes influence the volume and tone of posts related to cannabis in pregnancy. Finally, we will use these findings to inform recommendations to public health agencies, care providers, and other stakeholders and suggest future avenues for research. Our preliminary findings suggest that this work is feasible and that we have identified a sufficiently robust corpus of Tweets for more detailed analyses.

The final results of our review will be submitted for publication in a peer-reviewed journal, presented at academic conferences and shared through publicly available streams such as the professional and institutional social media accounts and web pages associated

with the research team. The results will provide insight into how frequently and in what context Twitter is being used to discuss cannabis use during pregnancy. We anticipate that this knowledge will help public health agencies and healthcare providers assess the messaging patients may be receiving on Twitter and develop communication strategies to counter misinformation, especially in geographical regions where legalization is recent or imminent. Most importantly, we foresee that our findings will assist expecting families in making informed choices about where they choose to access advice about using cannabis during pregnancy.

Acknowledgements

Author's Contributions: Conceptualization: LC, LE, MSQM, MK, DJC; Methodology: LC, LE, MSQM, MK, DJC; Writing- Original Draft: LC; Writing- Review & Editing: LC, LE, MSQM, SR, MW, MK, DJC; Supervision: DJC, MSQM; Funding Acquisition: DJC, MSQM. All authors read and approved the final version of this manuscript.

Funding Statement: This work was supported by a Canadian Institutes of Health Research Team Grant awarded to DJC [Funding Reference Number: CA3-170126].

Conflicts of Interest: None to declare.

Abbreviations:

API: application programming interface

PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
extension for scoping reviews

PCC: population, concept, context

NLTK: natural language toolkit

BERT: bidirectional encoder representations from transformers

US: United States

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Effects of
cannabis
during
pregnancy

Against

Support

Cannabis
exposure on
infants

Opinion

Medical
cannabis
(general)

Scientific
evidence
(Research)

Legalization
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Events